Province of British Columbia
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MINERAL RESOURCES DIVISION
Geological Survey Branch

GEOLOGY OF THE ADAMS PLATEAU – CLEARWATER – VAVENBY AREA

By P. Schiarizza and V.A. Preto

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Squaam Bay viewed from the east side of Adams Lake.

SUMMARY

The Adams Plateau – Clearwater – Vavenby map area covers 3500 square kilometres within the Shuswap Highland of south-central British Columbia. It is centred 80 kilometres north-northeast of Kamloops and is bounded by latitudes 51°00′ and 51°45′ north, and longitudes 119°30′ and 120°15′ west. The topography is dominated by the North Thompson River valley in the north and west, and the Adams Lake valley in the east.

The map area covers a belt of structurally complex low-grade metamorphic rocks which lies along the western margin of the Omineca Belt; it is flanked by high-grade metamorphic rocks of the Shuswap Complex to the east and by rocks of the Intermontane Belt to the west. The area is underlain mainly by Paleozoic metasedimentary and metavolcanic rocks of the Eagle Bay Assemblage and Fennell Formation. Late Devonian granitic orthogneiss locally intrudes Eagle Bay rocks. The Paleozoic rocks are cut by mid-Cretaceous granodiorite and quartz monzonite of the Raft and Baldy batholiths, and by Early Tertiary quartz feldspar porphyry, basalt and lamprophyre dykes. They are locally overlain by Eocene sedimentary and volcanic rocks of the Kamloops Group and by Miocene plateau lavas.

The Paleozoic rocks occur in four structural slices separated by southwesterly directed thrust faults. The upper three fault slices contain only Eagle Bay rocks, while the lowest slice comprises Eagle Bay strata structurally overlain by the Fennell Formation.

Rocks assigned to the Eagle Bay Assemblage range in age from Early Cambrian to Late Mississippian. They are in part correlative with Paleozoic successions in the Kootenay Arc and the Barkerville-Cariboo River area. The oldest Eagle Bay rocks comprise quartzites and quartzose schists overlain by a unit of predominantly mafic metavolcanic rocks and limestone which, at one locality, contains Lower Cambrian archaeocyathids. An undated package of grit, phyllite, carbonate and metavolcanic rocks overlies the Early Cambrian succession. It is locally overlain by calcareous phyllite and associated calc-silicate schist and skarn or by mafic metavolcanic rocks. The upper part of the Eagle Bay Assemblage comprises a Devono-Mississippian succession consisting of felsic metavolcanic rocks overlain by intermediate, locally alkalic, metavolcanics and fine to coarse-grained clastic metasediments. These Devono-Mississippian rocks may be separated from older portions of the Eagle Bay Assemblage by a significant unconformity. Late Devonian orthogneiss which intrudes Eagle Bay rocks is probably related to the felsic metavolcanics.

The Fennell Formation comprises imbricated oceanic rocks of Slide Mountain terrane which were tectonically emplaced onto Mississippian clastic rocks of the Eagle Bay Assemblage prior to synmetamorphic southwesterly directed folding and thrusting. The formation comprises two major divisions. The lower structural division is a heterogeneous assemblage of bedded chert, gabbro, diabase, pillowed basalt, sandstone, quartz-feldspar-porphyry rhyolite and intraformational conglomerate. Conodonts extracted from bedded chert range in age from Early Mississippian to Middle Permian while zircons extracted from quartz feldspar porphyry yield a Devonian uranium-lead age. The distribution of dated units indicates that the lower division is segmented into at least three and locally four imbricate thrust slices. The upper division consists almost entirely of pillowed and massive basalt, together with minor amounts of bedded chert and gabbro. Conodonts from two separate chert lenses within the division are respectively Early (?) Pennsylvanian and Middle Permian in age. The two divisions are therefore the same age, at least in part, and are inferred to be separated by a thrust fault.

Rocks of the Fennell Formation accumulated in a deep oceanic basin an unknown distance west of partially coeval rocks of the Eagle Bay Assemblage. Sandstone within the Fennell is very similar to Mississippian sandstone of the Early Bay Assemblage and may have been derived from it. Similarly, Devonian quartz-feldspar-porphyry rhyolite within the Fennell is like Devonian felsic volcanic rocks of the Eagle Bay Assemblage and may be an expression of the same igneous activity. The Fennell succession is inferred to comprise an imbricated marginal basin suite that was originally not far removed from the Eagle Bay terrane.

Deformation is predominantly Jura-Cretaceous and early Tertiary in age. The earliest macroscopic structures are the thrust faults which imbricate the Fennell Formation and separate it from Mississippian clastic rocks of the Eagle Bay Assemblage. East-verging, premetamorphic mesoscopic folds within the Fennell Formation probably also formed at this time. Tectonic emplacement of the Fennell Formation was followed by synmetamorphic southwesterly directed folding and associated thrust faulting which gave rise to several large overturned folds and the thrust faults which define the structural/stratigraphic panels which dominate the map pattern. The associated synmetamorphic schistosity is the dominant mesoscopic fabric within the area. These early structures are cut by postmetamorphic northwest-trending mesoscopic folds with associated steeply dipping crenulation cleavage and axial crenulation lineation, and by later west-trending macroscopic and mesoscopic folds which are synchronous with intrusion of the mid-Cretaceous Raft and Baldy batholiths. The youngest structures recognized are northeast-trending strike-slip faults and later northerly trending faults and associated folds which are Eocene in age.

Stratabound massive to semimassive sulphides containing mainly silver, lead and zinc occur on Adams Plateau where they are hosted by metasedimentary rocks within a succession of dominantly mafic metavolcanic Eagle Bay rocks of probable Early Cambrian age. Similar deposits occur within a correlative (?) interval near Mount McClennan.

Polymetallic precious and base metal massive sulphide occurrences are hosted by Devono-Mississippian felsic to intermediate metavolcanic rocks of the Eagle Bay Assemblage. They include the Homestake prospect and a number of other occurrences in the Sinmax Creek – Adams Lake area, as well as several showings along Birk Creek. Overlying alkalic rocks host similar mineralization at the recently discovered Rea deposit southwest of Johnson Lake.

Large-tonnage disseminated pyrite-pyrrhotite-chalcopyrite mineralization, such as that at the Harper Creek deposit, occurs within Eagle Bay rocks where they are intruded by Devonian orthogneiss. This spatial relationship suggests that the mineralization is Devonian in age and related to the orthogneiss, although it has been remobilized during later deformation and metamorphism.

Uranium-thorium-fluorite mineralization is hosted by a trachytic intrusive-extrusive complex within Devono-Mississippian Eagle Bay rocks along Foghorn and Lute creeks (Rexspar and Bullion showings).

The CC deposit is a cupriferous pyrite volcanogenic massive sulphide deposit hosted by oceanic basalts of the Fennell Formation east of Chu Chua Mountain.

The area also contains numerous vein deposits, as well as small pods of skarn mineralization near Cretaceous and Devonian granitic intrusions. The veins contain mainly silver-lead-zinc mineralization although gold was produced from the Sweet Home and Gold Hill veins within the Fennell Formation east of Dunn Lake.

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CHAPTER 1

INTRODUCTION

The Adams Plateau – Clearwater – Vavenby map area covers approximately 3500 square kilometres within the Shuswap Highland of south central British Columbia, between latitudes 51°00′ and 51°45′ north, and longitudes 119°30′ and 120°15′ west (Figure 1). It covers a belt of complexly deformed low-grade metamorphic rocks along the western margin of the Omineca Belt, represented mainly by the Eagle Bay Assemblage and Fennell Formation. These are flanked by high-grade metamorphic rocks of the Shuswap Complex to the east and by rocks of the Intermontane zone to the west (Figure 3). The area contains numerous mineral showings, some with modest production records, and has been the focus of intermittent and at times intense mineral exploration since the late 1800s. Recent important discoveries include the CC cupriferous-pyrite massive sulphide deposit within the Fennell Formation at Chu Chua Mountain (1978) and the Rea polymetallic massive sulphide deposit within the Eagle Bay Assemblage near Johnson Lake (1983).

LOCATION, ACCESS AND TOPOGRAPHY

The area described in this report is centred approximately 80 kilometres north-northeast of Kamloops (Figures 2 and 3). Easy access is provided northward from Kamloops to Louis Creek, Barriere, Clearwater and Vavenby by Highway 5 and the main line of the Canadian National Railway along the North Thompson River valley. A major all-weather access road branches eastward from Louis Creek to Squaam Bay and the west side of Adams Lake, and another extends eastward from the village of Barriere to the Barriere Lakes. The all-weather road along the west side of Adams Lake can also be reached via the Squilax-Celista road which branches northward from Highway 1 approximately 55 kilometres east of

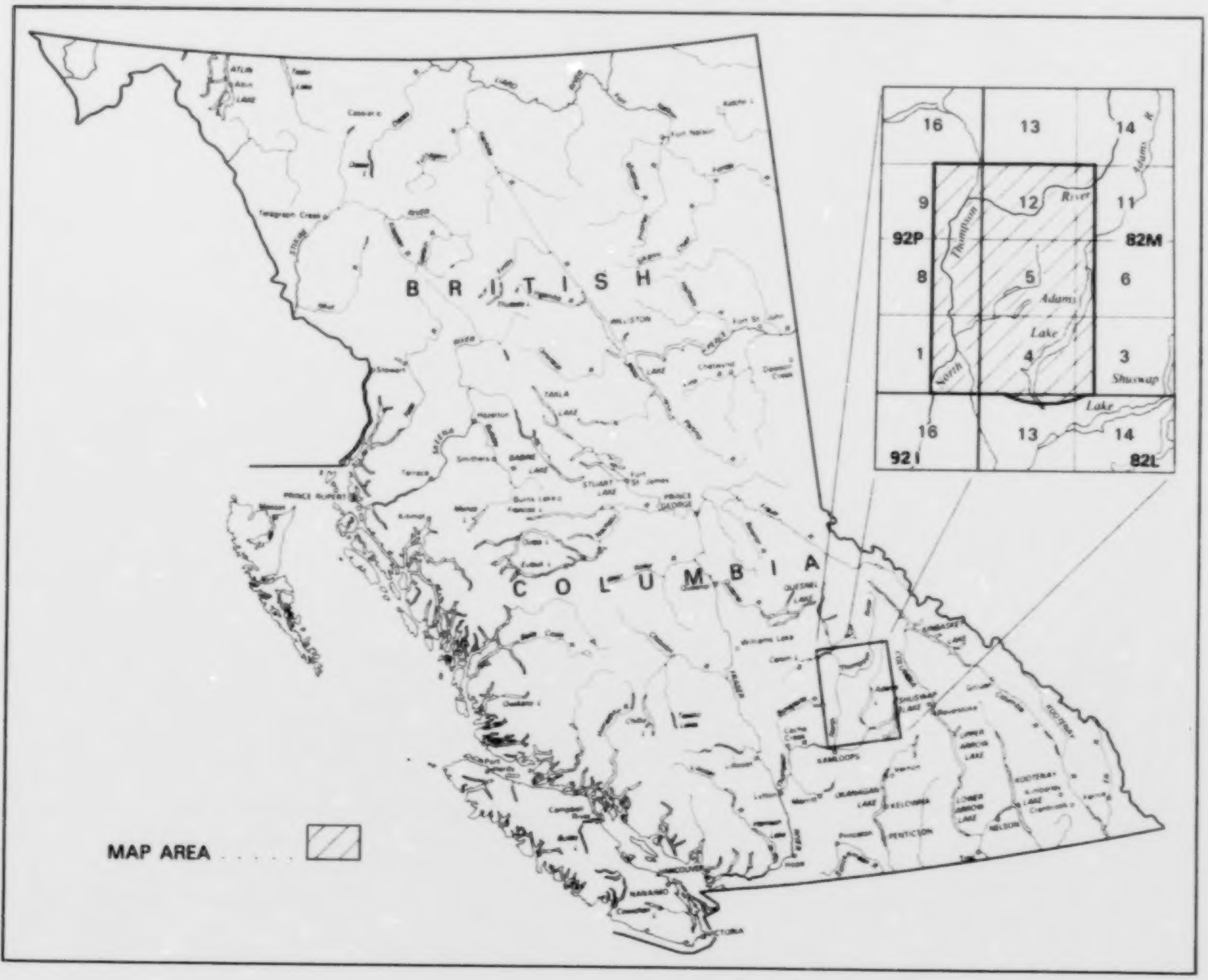

Figure 1. Location map.

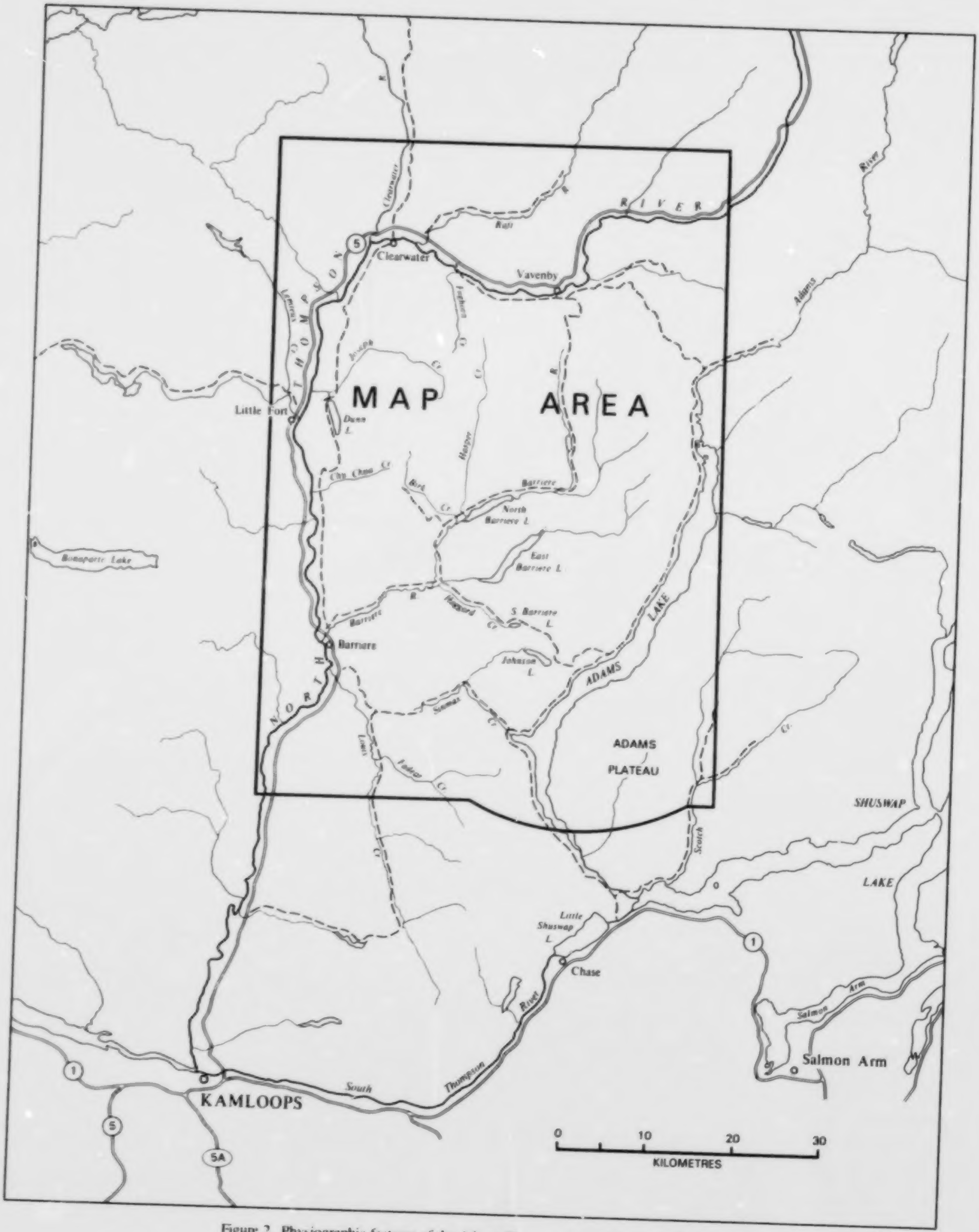

Figure 2. Physiographic features of the Adams Plateau – Clearwater – Vavenby area.

Kamloops; this road extends northwest from the north end of Adams Lake and connects with Highway 5 at Vavenby. A branch from the south end of the Adams Lake road also provides seasonal access to the Adams Plateau on the east side of Adams Lake. Access to other parts of the area is, in general, easily attained by an extensive network of old and new logging and forest service roads. Many of these, however, are negotiable only during the summer months, and then only with a four-wheel-drive vehicle or trail motorcycle.

Physiographically the area is part of the Shuswap Highland, a region of broad wooded mountains cut by deep valleys, which is bordered on the west by the more subdued Thompson Plateau and on the east by the rugged Monashee Mountains (Holland, 1964). The topography of the southern two thirds of the area is dominated by the north-trending valleys of the North Thompson River and Adams Lake (Figure 2). The intervening mountains are transected by a number of east-west valleys, the most important of which are those of Sinmax Creek, Barriere River and Joseph Creek. The northern part of the area is dominated by the west to northwest-trending segment of the North Thompson River valley, and the west to southwest-trending Raft River valley. Elevations range from a low of 400 metres along the North Thompson River to 2635 metres on Dunn Peak. Valley slopes are generally steep; those along the major north-trending valleys and the south-facing sides of the east-trending rivers and creeks are commonly sparsely vegetated and provide abundant rock exposures. North-facing slopes, and the rounded mountains and plateaus that cover most of the area, are generally heavily vegetated and bedrock is poorly exposed.

PREVIOUS GEOLOGICAL WORK

Previous geological investigations in the area were conducted mainly by officers of the Geological Survey of Canada. The earliest accounts are those of Selwyn (1872), Dawson (1879, 1895a, 1895b, 1898) and Daly (1915).

Uglow (1922) mapped along both sides of the North Thompson River valley from Joseph Creek to south of Barriere. He named the Fennell Formation and provided the first detailed descriptions of the formation. The Fennell Formation, together with adjacent rocks now included in the Eagle Bay Assemblage, was further described by Walker (1931) whose mapping included the area between Mount McClennan and Clearwater.

The Vernon map area, mainly to the south of the present study area, was mapped between 1945 and 1951 by A.G. Jones and H.M.A. Rice (Jones, 1959). Jones defined the Eagle Bay Formation as the uppermost formation within his Mount Ida Group, which he considered to be "Archean or younger" in age. Campbell (1963) mapped the Adams Lake sheet and recognized that rocks equivalent to the Eagle Bay Formation extend as far north as the Clearwater – Vavenby area. Mapping in the contiguous Bonaparte Lake sheet (Campbell and Tipper, 1971) established that Eagle Bay rocks extend as far west as Louis Creek, and also contributed to a better definition of the Fennell Formation.

Further investigations of rocks bordering the western margin of the Shuswap metamorphic complex, by Campbell and Okulitch (1973), Okulitch (1974, 1975), Okulitch, *et al.* (1975), and Okulitch and Cameron (1976), established some of the general aspects of the regional stratigraphy and structure. This information is incorporated in the Thompson – Shuswap – Okanagan map sheet, a 1:250 000-scale geological compilation of the western part of the southern Omineca Belt (Okulitch, 1979).

Descriptions of the geology and mineralization in the vicinity of the many mineral occurrences within the area are found in various Annual Reports of the British Columbia Minister of Mines dating from the late 1800s. Many of these are referred to in Chapter 4 of this paper. Further descriptions of specific mineral showings may be found in Assessment Reports on file at the Ministry's office in Victoria.

PRESENT STUDY

The earliest work incorporated in this paper is a study by Preto, in 1977, of the geology and mineralization in the vicinity of the Rexspar uranium-fluorine deposit along Foghorn Creek (Preto, 1978a, 1978b). The major part of the project, however, was initiated in 1978 when a geological survey of the Adams Plateau – Barriere Lakes area was begun. The project was aimed toward a better understanding of the stratigraphy and structure of rocks along the west side of the Shuswap Complex, especially as it pertained to the nature and setting of the numerous base and precious metal deposits within the area. Geological mapping was carried out in 1978 by V.A. Preto and senior field assistants G. McLaren and P. Schiarizza, and summarized by Preto (1979). The project was continued in 1979, despite the forced absence of V.A. Preto, when it was capably supervised by G. McLaren, with assistance from W.J. McMillan. Mapping during 1979 was carried out by G. McLaren, P. Schiarizza and L. Diakow (Preto *et al.*, 1980). The Adams Plateau – Barriere Lakes portion of the project was completed during the 1980 field season by V.A. Preto and senior field assistant D. Forster (Preto, 1981). At the same time a subsidiary project was begun by P. Schiarizza, then a graduate student at the University of Calgary, aimed at better understanding the internal stratigraphy and structure of the Fennell Formation and its relationship to adjacent Eagle Bay rocks. This work covered the western part of the area, from the Barriere River to Clearwater, and was completed during the 1981 field season (Schiarizza, 1981, 1982, 1983). Results of the 1978-1981 mapping program were subsequently published as the Adams Plateau – Clearwater map sheet (Preliminary Map 56, Schiarizza and Preto, 1984). The final phase of the project was completed in 1985 when the northeastern part of the area, centred near the town of Vavenby, was mapped by P. Schiarizza (Schiarizza, 1986a, 1986b).

ACKNOWLEDGMENTS

In addition to the geologists previously named who were involved in the project, the writers would like to acknowledge the capable assistance provided by the following people: Norman Ryder and Gregory Gudgeon (1978); Ian MacGregor (1979); Glen Gaudin, Brian McKee, Blair Krueger and Mark Stevens (1980); Bruce Gaiesky (1981); and Peter Fischl (1985). We are also indebted to M.J. Orchard of the Geological Survey of Canada for conodont identifications and to R.L. Armstrong and B. Ryan of The University of British Columbia for radiometric dating. Discussions with G.P.E. White and Trygve Höy of this Ministry, L.C. Struik of the Geological Survey of Canada, P.S. Simony of the University of Calgary, and numerous industry geologists interested in the area are gratefully acknowledged. The hospitality of Vern and Betty Wilson of East Barriere Lake Resort, of Bob and Betty Anderson of Agate Bay Resort and of Roy and Joan Unterschultz of Vavenby is very much appreciated.

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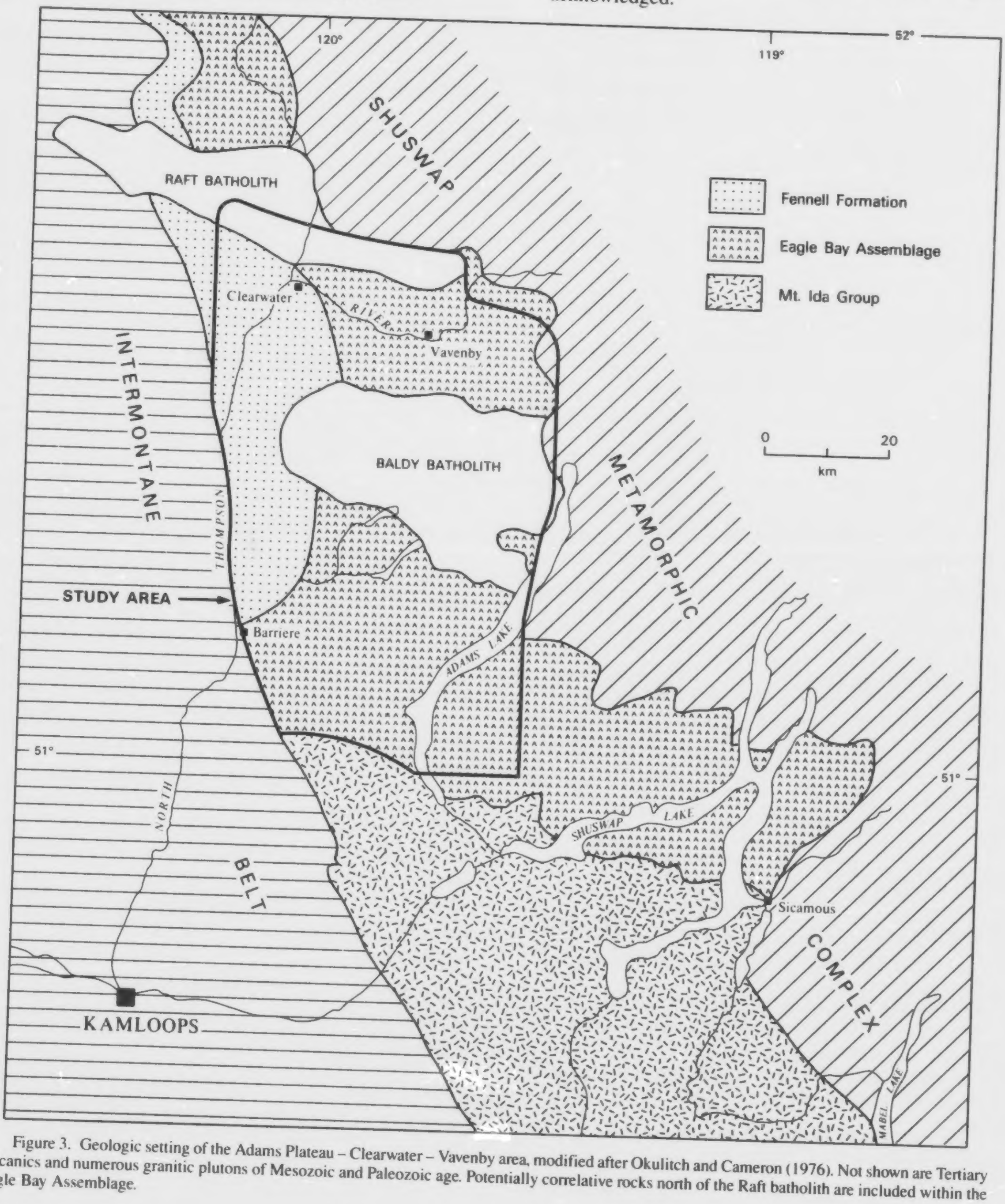

Figure 3. Geologic setting of the Adams Plateau – Clearwater – Vavenby area, modified after Okulitch and Cameron (1976). Not shown are Tertiary volcanics and numerous granitic plutons of Mesozoic and Paleozoic age. Potentially correlative rocks north of the Raft batholith are included within the Eagle Bay Assemblage.

CHAPTER 2

LITHOLOGIC UNITS

INTRODUCTION

The Adams Plateau – Clearwater – Vavenby map area is underlain mainly by Paleozoic rocks of the Eagle Bay Assemblage and Fennell Formation. The Eagle Bay Assemblage comprises Early Cambrian to Mississippian metasedimentary and metavolcanic rocks that are locally intruded by Devonian orthogneiss. They resemble, in part, North American miogeoclinal strata to the east, and are included within the parautochthonous or "pericratonic" Kootenay terrane of Price *et al.* (1985). The Fennell Formation comprises Devonian to Permian oceanic rocks of the Slide Mountain terrane which were tectonically emplaced over Mississippian rocks of the Eagle Bay Assemblage in early Mesozoic time. The Fennell and Eagle Bay rocks were deformed and metamorphosed together during the Jura-Cretaceous Columbian orogeny; the metamorphic grade is lower greenschist through most of the area, but increases sharply to amphibolite facies in places along the eastern and northeastern margins. The Fennell and Eagle Bay successions are cut by mid-Cretaceous granitic rocks of the Raft and Baldy batholiths, and by Early Tertiary quartz feldspar porphyry, basalt and lamprophyre dykes. They are locally overlain by Eocene sedimentary and volcanic rocks of the Kamloops Group and by Miocene plateau lavas.

Paleozoic rocks in the study area occur in four structural slices separated by southwesterly directed thrust faults (Figure 6, in pocket, and Figure 7). The upper three fault slices contain only Eagle Bay rocks, while the lowest slice comprises Eagle Bay strata structurally overlain by rocks of the Fennell Formation.

The fourth (upper) Eagle Bay fault slice consists of an inverted sequence of mafic metavolcanic rocks and limestone of Unit EBG, structurally overlain by quartzites, grits and quartz mica schists of Unit EBH. Rocks within this fault slice are dated as Early Cambrian and (?) older on the basis of fossil archaeocyathids collected from the Tshinakin limestone member of Unit EBG.

At the base of the third Eagle Bay fault slice is a succession consisting dominantly of quartzites, grits and quartz mica schists (Unit EBQ) intruded by a large sheet of Devonian granitic orthogneiss. Unit EBQ is not dated, but is tentatively correlated with the lithologically similar Early Cambrian and/or older rocks of Unit EBH. The upper part of Unit EBQ locally includes significant proportions of chlorite schist and limestone and may correlate with Unit EBG. Throughout most of the third fault slice, Unit EBQ is overlain by a Devono-Mississippian succession comprising felsic to

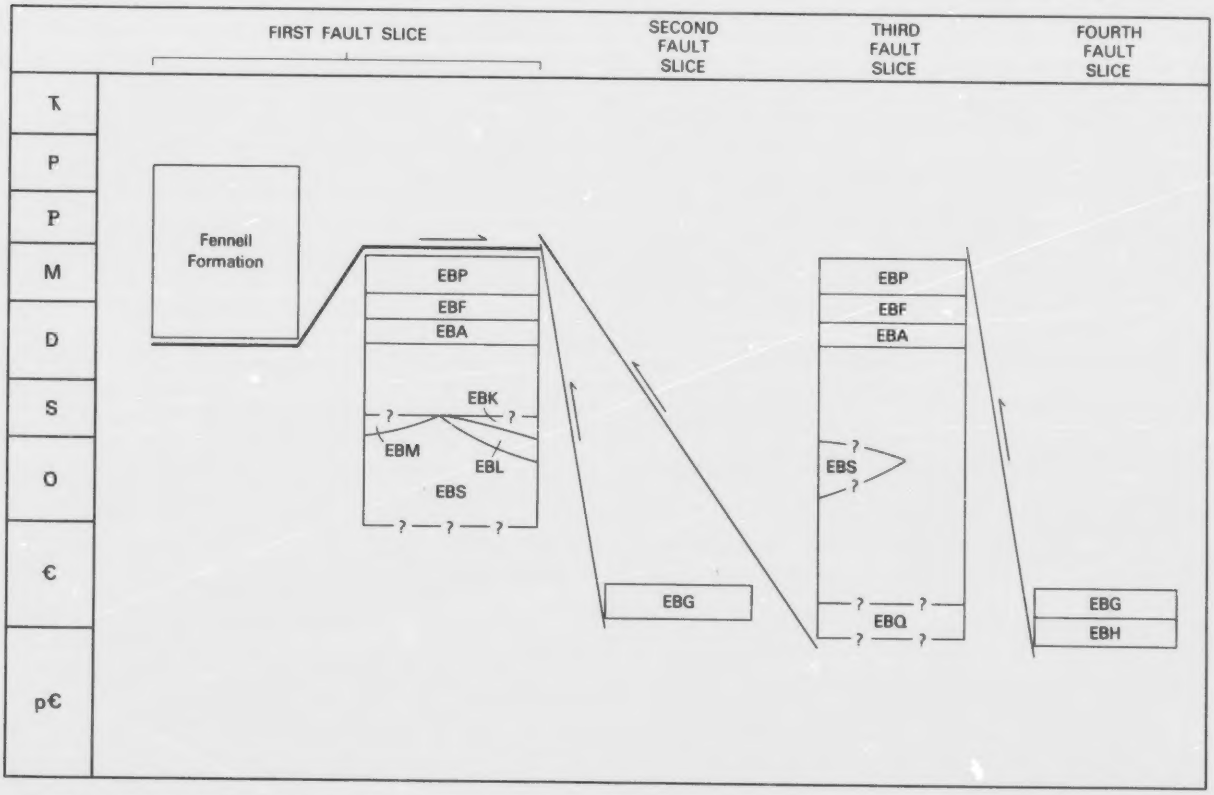

Figure 7. Correlation chart showing ages and structural/stratigraphic relationships of rock units within the Adams Plateau – Clearwater – Vavenby area.

intermediate metavolcanic rocks (Units EBA and EBF) intercalated with and overlain by dark grey phyllite, sandstone and grit (Unit EBP). These rocks were not dated within the third fault slice, but are correlated with an identical sequence within the first fault slice. In the lower slice, Unit EBA yielded a Middle Devonian radiometric age, and several collections of Mississippian conodonts were made from Unit EBP. Locally within the third fault slice, Units EBA and EBF are absent, and Units EBQ and EBP are separated by a succession of schistose sandstones and grits that are assigned to Unit EBS.

The second Eagle Bay fault slice consists of mafic metavolcanics, limestone (including the prominent Tshinakin limestone member) and related rocks of Unit EBG. These rocks are not dated within this slice, but are readily correlated with lithologically identical rocks of the uppermost fault slice, within which the Tshinakin limestone member has yielded Early Cambrian archaeocyathids. The second fault slice is not recognized north of the Barriere River strike-slip fault, where rocks of the third slice lie directly above the first.

The first and lowest fault slice comprises a succession of Eagle Bay rocks structurally overlain by rocks of the Fennell Formation. The base of the Eagle Bay succession is a heterogeneous assemblage of phyllitic sandstone and grit, intercalated with carbonate and mafic to felsic volcanic and volcaniclastic rocks. The age of these rocks is unknown; they are assigned to Unit EBS and correlated with lithologically similar rocks which locally lie above Unit EBQ in the third fault slice. Within the first fault slice, Unit EBS is overlain by Devono-Mississippian rocks of Units EBA, EBF and EBP, but is locally separated from them by either limestone, calc-silicate schist and skarn of Units EBL and EBK, or by mafic metavolcanic rocks of Unit EBM. The Fennell Formation is an internally imbricated oceanic assemblage consisting mainly of basalt, chert and gabbro, intercalated with lesser amounts of quartz-feldspar-porphyry rhyolite, sandstone, metatuff, limestone, and intraformational conglomerate. It comprises the upper part of the first structural slice, but is separated from Mississippian Eagle Bay rocks of Unit EBP by an early, easterly directed thrust fault; this thrust formed prior to the southwesterly directed structures which dominate the structural pattern of the area.

EAGLE BAY ASSEMBLAGE

INTRODUCTION

The name "Eagle Bay" was first proposed by Jones (1959) for a series of low-grade metasedimentary and metavolcanic rocks that outcrop between Shuswap and Adams lakes in Vernon map area. They comprised the uppermost formation of his Mount Ida Group, which he assigned an "Archean or Younger" age. Campbell (1963) mapped the Adams Lake sheet and recognized that rocks equivalent to the Eagle Bay Formation extended as far north as the Clearwater – Vavenby area. He collected Late Paleozoic fossils from a single limestone unit within the succession and suggested that this might be the age of the entire package. Further work by Campbell and Tipper (1971) in the Bonaparte Lake map area established that Eagle Bay rocks along Adams Lake extended northwestward to the Barriere River. Following these correlations, the name Eagle Bay Formation came to be used for the rocks underlying a broad area lying west of the Shuswap metamorphic complex from Clearwater southeast to Shuswap Lake (Campbell *et al.*, 1976) (Figure 3).

More recently, Okulitch (1979) revised the geology of the region and correlated the Eagle Bay succession with the stratigraphy of the Kootenay Arc, on the east side of the Shuswap Complex. He correlated part of the Eagle Bay succession with the Lower Paleozoic Lardeau Group, and part (mainly Unit EBP of this report) with the Carboniferous Milford Group which, in the arc, overlies the Lardeau Group with angular unconformity. He allowed that sub-Lardeau Group correlatives might also be present within the Eagle Bay succession and, specifically, was correct in correlating the Tshinakin limestone member (EBGt) of the Eagle Bay Formation with the Lower Cambrian Badshot Formation of the Kootenay Arc.

During the present study it was established that, within the map area, the Eagle Bay Assemblage comprises four northwest-dipping thrust sheets. Stratigraphic units can be matched from one sheet to another, suggesting that the bounding faults are not the loci of extremely large displacements. Although many lithologic units within the assemblage remain undated, it has been established that the Eagle Bay includes a Lower Paleozoic (and older?) succession of clastic metasediments, carbonate and mafic metavolcanic rocks, and an overlying Devono-Mississippian succession of felsic to intermediate metavolcanic rocks and clastic metasediments. Generalized correlations with Kootenay Arc (Okulitch, 1979) and Cariboo Mountains – Quesnel Highlands (Struik, 1986) stratigraphy are corroborated by the present study, but differ in detail from those made by previous workers. (Figure 8).

UNIT EBH

Unit EBH consists mainly of quartzite, chlorite-muscovite-quartz schist and grit, intercalated with minor amounts of grey phyllite and dolomitic chlorite schist. It outcrops in the northern part of the map area, between the Raft and Baldy batholiths, where it sits structurally above Unit EBG within the uppermost (fourth) Eagle Bay fault slice (Figures 6 and 7). It is the structurally highest unit of the Eagle Bay Assemblage exposed within the area. Unit EBH is overturned, however, and may be on the lower limb of a large nappe structure. It lies stratigraphically beneath the Early Cambrian rocks of Unit EBG and is therefore (together with potentially correlative rocks of Unit EBQ) the oldest stratigraphic unit known within the area (Figure 8).

Unit EBH outcrops most extensively between Robert and Chuck creeks, where it lies structurally above Unit EBG in the core of the west-trending Graffunder Lakes synform (Figure 5, section H-H′, in pocket). Several occurrences of graded grit beds in this area indicate that the unit is overturned. A belt of similar metasedimentary rocks occurs internally within Unit EBG on the south limb of the synform; graded beds along the southern margin of this belt are also overturned. This belt is inferred to comprise Unit EBH rocks infolded into Unit EBG in a southerly overturned anticline (Figure 5, section H-H′). This belt of infolded(?) rocks also occurs immediately west of the Chuck Creek fault (with apparent right-lateral displacement) but is absent farther west, where it is inferred to pinch out against the underlying

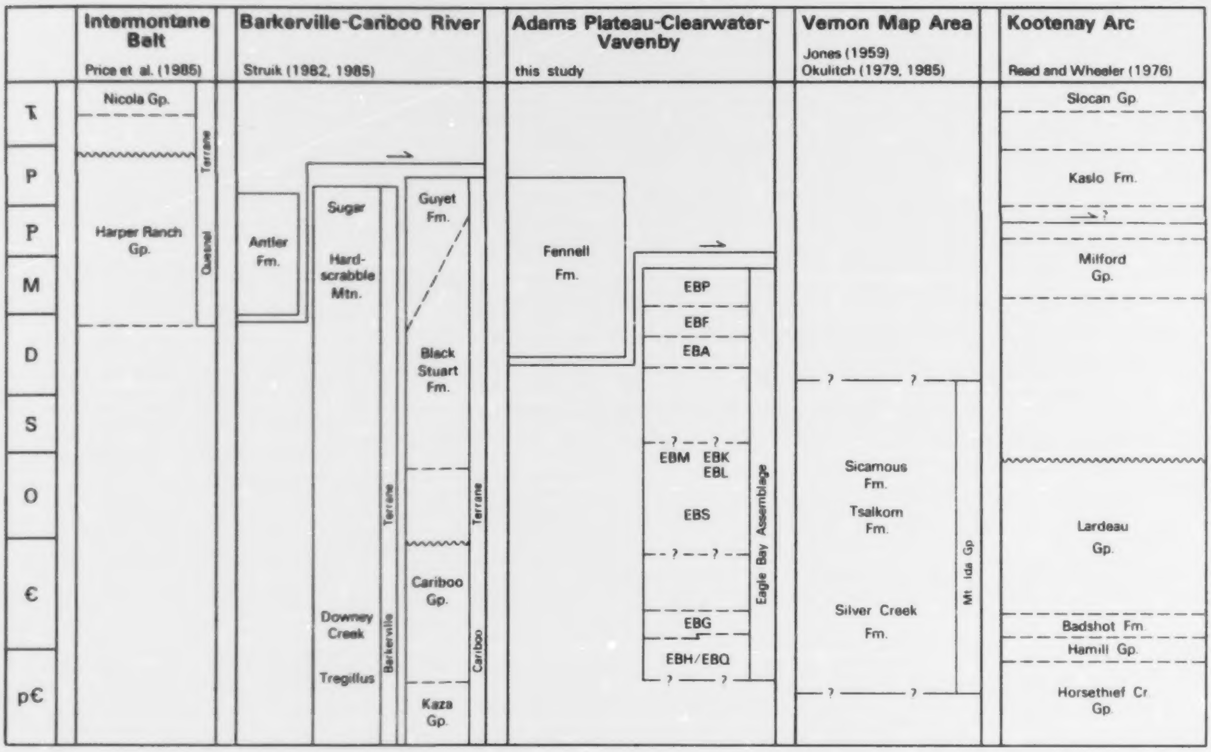

Figure 8. Regional correlation chart.

Vavenby thrust fault separating the third and fourth Eagle Bay fault slices (Figure 4, in pocket).

Unit EBH also outcrops north of Vavenby, west of the North Thompson River. There it lies structurally above Unit EBG in an overturned, steeply northeast-dipping belt that is truncated by the Raft batholith to the north and by a north-trending fault (the northerly extension of the Chuck Creek fault) within the North Thompson River valley to the east.

The dominant lithologies within Unit EBH are light to medium grey and greenish grey chlorite-muscovite-quartz schists and platy quartzites. These lithologies typically grade into one another across indistinct contacts, but may be intercalated as distinct, locally graded beds ranging from several centimetres to tens of centimetres in thickness. Where evident, the sand-sized clastic grains are mainly light to medium grey quartz, with relatively minor amounts of feldspar and blue quartz. Relatively massive, light grey to white quartzite and sericitic quartzite occur locally within the platy quartzites and schists over intervals up to 10 metres in thickness. Lenses of medium to dark grey phyllite were noted rarely.

Granule conglomerate occurs mainly near the stratigraphic top of Unit EBH, close to the contact with Unit EBG. Locally it dominates intervals several tens of metres thick. The grit within these intervals is typically well bedded, with beds ranging up to 1 metre in thickness. The beds are commonly graded and intercalated with relatively thin horizons of quartz-chlorite-muscovite schist. Grit beds are mainly light to medium grey in colour and comprised of quartz and subordinate feldspar clasts floating in a more or less schistose quartz-chlorite-sericite matrix. In places, however, much of the grit is medium to dark green in colour due to a chlorite-rich matrix; the green grit beds commonly contain a high proportion of feldspar clasts.

Exposures of massive, white-weathering granule to pebble conglomerate were noted within Unit EBH at one locality north of Graffunder Lakes. These rocks comprise mainly clasts of quartz and subordinate feldspar, 2 to 6 millimetres in size, within a massive to weakly foliated matrix of quartz and sericite. Locally, they contain clasts of vein quartz up to 1.5 centimetres in size.

Rusty weathering dolomite-chlorite schist is locally intercalated with the clastic metasediments of Unit EBH, mainly near the contact with Unit EBG. These schists resemble those found within overlying Unit EBG and were probably derived from mafic tuffs.

The rocks within Unit EBH have not been dated. However, they lie stratigraphically beneath Unit EBG which is, at least in part, of Early Cambrian age. Local intercalations of characteristic EBG and EBH lithologies in the vicinity of the contact suggest that it is conformable. Unit EBH is therefore inferred to be Early Cambrian and/or older in age.

UNIT EBG

Unit EBG consists mainly of calcareous chlorite schist derived from mafic volcanic and volcaniclastic rocks.

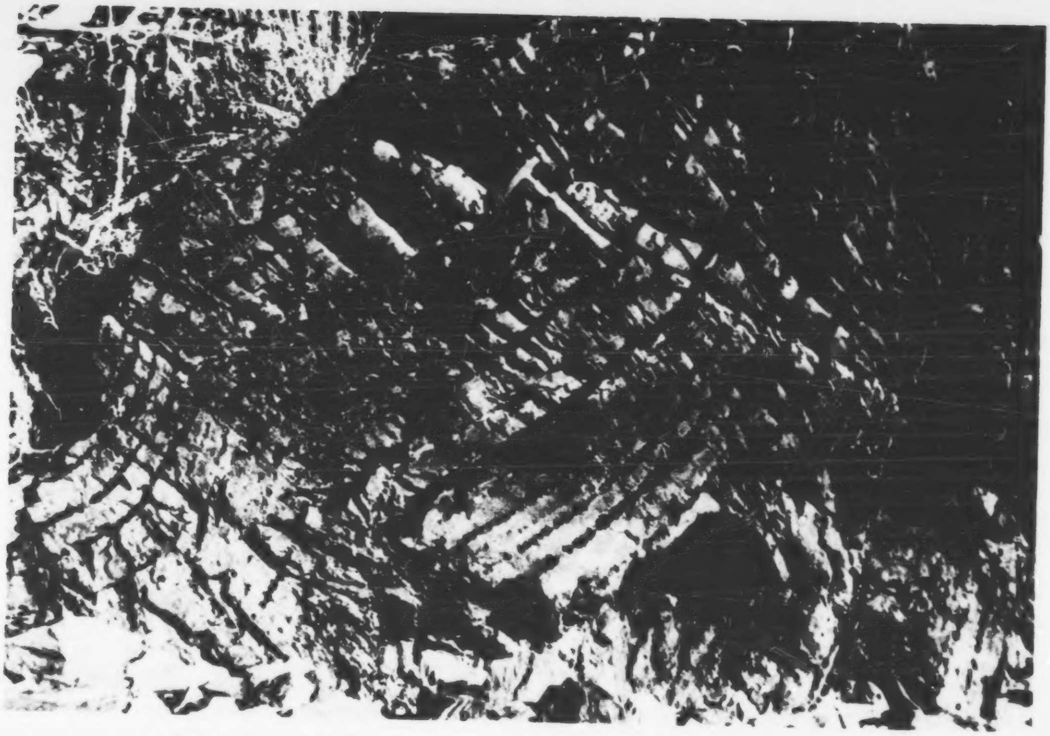

Plate 1. Vesicular greenstone of Unit EBG, Adams Lake shoreline north of Squaam Bay.

Plate 2. Silty phyllite containing thin beds of very fine-grained quartzite of Unit EBGs, south of Johnson Lake.

Limestone, including the prominent Tshinakin limestone member, is common within the unit, and quartzite, grit, phyllite, dolostone, conglomerate and intermediate to felsic metavolcanic rocks are present locally. Unit EBG outcrops most extensively within a northeasterly dipping belt which was traced from North Barriere Lake, where it is truncated by the Barriere River fault, for 40 kilometres southeastward to Adams Plateau. This belt of Unit EBG rocks comprises the second Eagle Bay fault slice. It lies structurally above Units EBP, EBF and EBA of the first fault slice, and is structurally overlain by Unit EBQ of the third fault slice. Unit EBG also outcrops in the Vavenby area where, together with structurally overlying rocks of Unit EBH, it comprises an overturned sequence which is the highest structural slice exposed in the area (Figure 6). The Tshinakin limestone member in this upper fault slice has recently yielded Early Cambrian archaeocyathids and this age is considered the most likely for the entire unit.

The belt of Unit EBG rocks which comprises the third fault slice displays an internal stratigraphy which is locally discontinuous, but recognizable throughout most of the length of the belt. It will be discussed with reference to a schematic section drawn through the unit on the west shore of Adams Lake (Figure 9). This belt of rocks is presumed to be right-way-up, although no top determinations were made within it.

Below the Tshinakin limestone, Unit EBG is dominated by calcareous chlorite schist that is locally intercalated with thin carbonate horizons. Metasedimentary rocks, mainly siliceous and graphitic phyllite, limestone and quartzite, are locally prominent near the base of the Tshinakin limestone, and host the lead-zinc-silver mineralization on Adams Plateau. Polymictic conglomerate occurs locally near the base of the unit. The chlorite schists are typically medium to dark green, fine grained and well foliated, with a platy splitting habit. They were derived largely from fine-grained mafic tuffs and related epiclastic rocks. Fragmental schists derived from coarser volcaniclastic rocks are common, and contain clasts of chlorite schist and greenstone that are similar in composition to the matrix. The clasts range from a few millimetres to several tens of centimetres in size and are flattened and foliated to varying degrees within the plane of the matrix schistosity. Relatively massive greenstone, which may be vesicular and/or amygdaloidal (Plate 1), is present locally and was derived from massive flows. Pillowed greenstone was noted at a few localities but is not common. The schists are composed mainly of chlorite, actinolite, epidote, albite and calcite. Quartz and sphene are also usually present, and magnetite commonly occurs as distinct octahedra 1 or 2 millimetres in size. White, finely crystalline calcite typically forms discrete lenses or veins up to several centimetres wide.

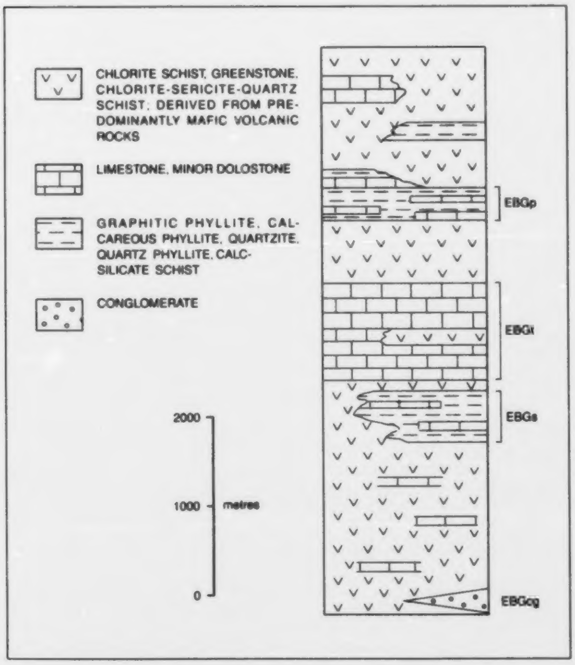
CHLORITE SCHIST, GREENSTONE, CHLORITE-SERICITE-QUARTZ SCHIST; DERIVED FROM PREDOMINANTLY MAFIC VOLCANIC ROCKS
LIMESTONE, MINOR DOLOSTONE
GRAPHITIC PHYLLITE, CALCAREOUS PHYLLITE, QUARTZITE, QUARTZ PHYLLITE, CALC-SILICATE SCHIST
CONGLOMERATE
2000
1000
0
metres
EBGp
EBGt
EBGs
EBGcg

Figure 9. Schematic stratigraphic section through Unit EBG along Adams Lake.

Pale grey to greenish grey chlorite-sericite-quartz phyllite occurs locally within the lower part of Unit EBG, but is not common. In places the phyllite contains relict grains of feldspar and quartz and was probably derived from relatively more felsic volcanic and/or volcaniclastic rocks.

Carbonate is intercalated with the chlorite schist throughout the lower part of Unit EBG, but is a subordinate component. It consists mainly of light grey, finely crystalline limestone, although beds of rusty weathering chloritic dolostone occur locally. The carbonate intervals range from thin horizons only a few tens of centimetres thick to tabular lenses more than 10 metres thick. Few are sufficiently thick or persistent enough to be portrayed on the geological map.

Polymictic conglomerate (EBGcg) occurs at the structural base of Unit EBG on both sides of Adams Lake; it was also mapped at two localities east of North Barriere River, where it appears to be several hundred metres above the base of the unit (Figure 4, in pocket). The conglomerate consists of poorly sorted pebbles and cobbles (up to 15 centimetres in longest dimension) of various rock types within a fine-grained, light to medium green calcareous chlorite-sericite-quartz schist matrix. The clasts are generally matrix-supported and usually comprise 60 to 80 per cent of the rock. They include, in order of decreasing abundance, light grey to greenish grey quartzite, light to medium grey limestone, rusty dolostone, green chloritic schist, vein quartz, and light to medium greenish grey phyllite and quartz phyllite. Most clasts are more or less flattened parallel to the schistosity of the matrix; schistosity in strongly foliated schist and phyllite clasts is continuous with that of the matrix.

Lenses of metasedimentary rocks (EBGs), that consist largely of siliceous phyllite, calcareous phyllite, impure limestone and quartzite, occur locally beneath the Tshinakin limestone. Invariably they are separated from it by several metres to tens of metres of chlorite schist. These metasedimentary lenses range up to several hundred metres in thickness, but pinch out abruptly and pass along strike into mafic metavolcanic rocks. Locally they include intercalations of chlorite schist that are probably derived from mafic tuffs. The most prominent metasedimentary lens occurs on Adams

Plate 3. White bluffy outcrops of the Tshinakin limestone member of Unit EBG, north of Johnson Lake.

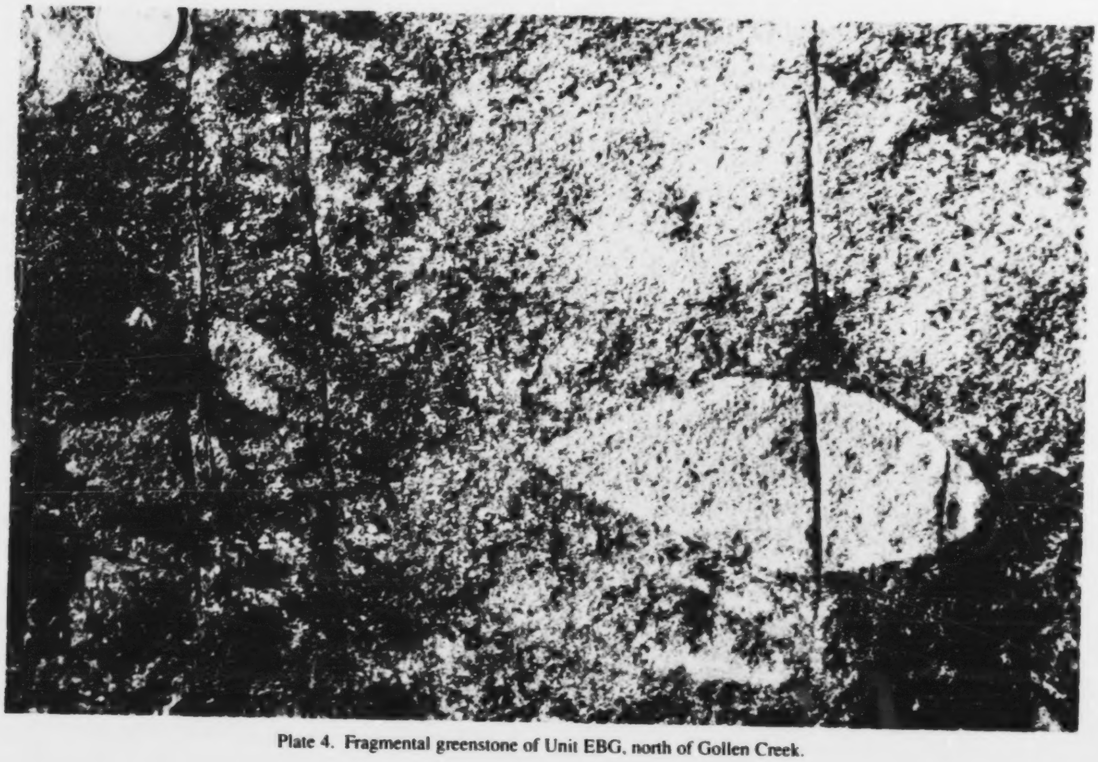

Plate 4. Fragmental greenstone of Unit EBG, north of Gollen Creek.

Plateau, where the metasediments outcrop in the core of the Nikwikwaia synform and host a number of lead-zinc-silver deposits. A similar sequence of rocks can be traced from the west shore of Adams Lake for 3 kilometres to the northwest, where it is truncated by a north-trending fault. The metasediments are absent west of the fault, but 5 kilometres to the northwest they occur again and can be traced for 4.5 kilometres further to the northwest, where the belt of Unit EBG rocks is offset along the northeast-trending Johnson Creek fault. Similar metasedimentary rocks are of only minor importance directly to the northwest, between South and East Barriere Lakes, but are again common at the northwest end of the belt, east of the North Barriere River.

The metasedimentary rocks within these lenses consist largely of medium to dark grey graphitic and/or siliceous phyllites that grade to light to dark grey platy siltite and very fine-grained platy sericitic quartzite (Plate 2). Relatively pure, light to medium grey, massive to platy quartzite occurs locally. On Adams Plateau it forms a prominent marker (EBGq) at the base of the metasedimentary lens and outlines the Nikwikwaia synform. Another quartzite sequence, which locally includes lenses of siliceous dolomite, can be traced for 5 kilometres between East and North Barriere Lakes. It (EBGq) lies above medium to dark grey siliceous argillite and phyllite that contains minor amounts of platy quartzite and quartz-granule conglomerate (Unit EBGs, Figure 4). Medium to dark grey phyllitic limestone and calcareous phyllite are common within the three metasedimentary lenses that occur between South Barriere Lake and the Adams Plateau. On Adams Plateau the limestone horizons are commonly intercalated with grey and green calc-silicate rocks and skarn.

The Tshinakin limestone (EBGt) is the most prominent marker within Unit EBG. It consists mainly of light grey to white, finely crystalline limestone and locally approaches 1000 metres in thickness. The limestone is typically massive, although flaggy partings 2 to 15 centimetres apart and colour-banded intervals in shades of light to dark grey occur in places. Buff-weathering dolostone is present locally, and lenses of chlorite schist up to several tens of metres thick occur here and there throughout the unit. The Tshinakin limestone often forms prominent bluffy outcrops (Plate 3), and can be traced continuously for about 24 kilometres from Pisima Mountain on the Adams Plateau to South Barriere Lake, where it terminates abruptly. It is inferred that this termination marks an original interruption in the carbonate bank or reef complex because underlying (for example, EBGq) and overlying (for example, EBGp) elements of Unit EBG continue uninterrupted to the northwest across this apparent break. Thirteen kilometres farther to the northwest, a similar limestone horizon, which is approximately 700 metres thick, occurs at about the same stratigraphic level. It is considered to be correlative with the Tshinakin member, and probably represents another reef complex.

Fragmental chlorite schist and greenstone, that are identical to the mafic metavolcanic rocks which dominate the lower part of Unit EBG, directly overlie the Tshinakin limestone. Between Adams and North Barriere lakes these rocks are overlain by a persistent unit (EBGp) that is dominantly medium to dark grey phyllite, calcareous phyllite and phyllitic limestone. Locally this horizon includes rusty weathering feldspathic ankerite-sericite-quartz phyllite that was probably derived from a tuff of intermediate composition.

The uppermost part of Unit EBG is not well exposed but appears to consist mainly of chlorite schists and fragmental chlorite schists, similar to those which characterize the lower part of the unit. Intercalated with these mafic metavolcanic rocks are horizons of quartzite, siliceous phyllite, limestone and feldspathic chlorite-sericite-quartz phyllite (intermediate metatuff).

In the Vavenby area Unit EBG rocks outcrop in the fourth fault slice between the Raft and Baldy batholiths. The unit outcrops most extensively on the south side of the North Thompson River, where it occurs in a number of fault blocks separated by late northerly trending faults; it also outcrops on the north side of the river, south and east of the McCorvie Lakes. Unit EBG occurs at the base of the upper slice; in eastern exposures it is structurally overlain by Unit EBH. The succession is overturned and is inferred to comprise the lower limb of a large nappe structure (Figure 5, section H-H′). Unit EBG is separated from underlying rocks of the third fault slice by the Vavenby thrust fault (Figure 6).

Within the fourth fault slice Unit EBG is dominated by calcareous chlorite schists and limestones identical to those which characterize the unit within the second fault slice. The chlorite schist is typically medium to dark green, fine grained, and moderately to strongly fissile. Local intervals within the unit are dolomitic and weather brown or rust coloured. Relatively coarse fragmental rocks are present locally (Plate 4), as is massive greenstone that was probably derived from massive flows. Feldspar and/or hornblende crystals are conspicuous in places and may be accompanied by quartz crystals and abundant sericite where the rocks are derived from relatively more felsic volcanics. Hornblende-feldspar-quartz-sericite-chlorite schist is most abundant in the vicinity of Chuck Creek where it is intercalated with light to medium grey phyllite, fine-grained quartzite and limestone; this interval has been distinguished on the map as Unit EBGf.

Light grey to greenish grey quartzite, grit and chlorite-sericite-quartz schist occur locally within Unit EBG of the fourth fault slice, but are not common. These rocks resemble rocks which characterize Unit EBH and occur mainly in close proximity to the contact with Unit EBH.

Light grey, finely crystalline limestone occurs, at least locally, throughout most of the Unit EBG succession in the fourth fault slice, but rarely constitutes mappable horizons. However, a thick, well-exposed limestone unit, which outcrops on both sides of the North Thompson River near Vavenby (Plate 5), is comparable in thickness to the Tshinakin limestone member of the second fault slice, and is correlated with it (Unit EBGt, Figure 4). Fossil archaeocyathids (Plate 6) were found within this unit 4 kilometres northwest of Vavenby, indicating an Early Cambrian age (Appendix 1). This is the only age control currently known for Unit EBG and the stratigraphically underlying rocks of Unit EBH.

Plate 5. Outcroppings of the Tshinakin limestone member of Unit EBG, west of Avery Lake; Granite Mountain is to the west in the top left corner of the photograph.

Plate 6. Early Cambrian archaeocyathid from the Tshinakin limestone, 4 kilometres northwest of Vavenby.

UNIT EBQ

Unit EBQ consists of micaceous quartzite, grit, phyllite and quartz mica schist, accompanied by minor amounts of chlorite schist, limestone, calcareous phyllite, calc-silicate schist and amphibolite. It occurs within the third Eagle Bay fault slice, where it is overlain by Devono-Mississippian rocks of Units EBA, EBF and EBP, and locally by Unit EBS (Figures 6 and 7). Its stratigraphic base is not seen because it is underlain by Devonian orthogneiss of Unit Dgn. South of the Barriere River fault, Unit EBQ (designated as Unit SDQ by Schiarizza and Preto, 1984) occupies a northwest-trending belt between Adams and North Barriere lakes. The southwest-dipping rocks within this belt are underlain by Unit Dgn and are juxtaposed, to the southwest, against northeast-dipping Unit EBG rocks of the second fault slice, across what is inferred to be a northeast-dipping thrust fault. North of the Barriere River fault, Unit EBQ occurs mainly on the north and south limbs of a composite east-trending synformal structure between the Raft and Baldy batholiths (Figure 5, sections H-H′ and I-I′). It is stratigraphically overlain by Devono-Mississippian Eagle Bay rocks, and locally by Unit EBS of uncertain age. East of the Chuck Creek fault, however, it is locally structurally overlain by Unit EBG of the fourth Eagle Bay fault slice. Unit EBQ is underlain by Devonian orthogneiss (Unit Dgn) on the south limb of the synformal structure, north of the Baldy batholith (Figure 4). Between Granite Mountain and Barriere River (where it is designated as Unit EBQgn) it is intruded by bodies of orthogneiss and by sills (?) of quartz-eye sericite schist (quartz porphyry) that may be directly related to overlying felsic volcanic rocks of Unit EBA. North of North Thompson River, Unit EBQ rocks are juxtaposed directly above Fennell Formation rocks of the first fault slice.

In most areas Unit EBQ rocks contain greenschist facies metamorphic mineral assemblages, as do other Paleozoic rocks throughout the map area (with the exception of the contact aureoles around the Raft and Baldy batholiths). However, eastern EBQ exposures, particularly in the vicinity of Spapilem and Reg Christie creeks, are at amphibolite grade. The transition to higher metamorphic grade is rapid, but is apparently not faulted.

The dominant rock type within Unit EBQ is light to medium (rarely dark) grey to brownish grey, fine to medium-grained micaceous quartzite. It is generally well foliated, with a platy aspect due to more or less regularly spaced micaceous partings between plates and lenses of quartz-rich rock that are several millimetres to several centimetres thick. The mica is typically muscovite with minor amounts of chlorite, but includes biotite in higher metamorphic grade exposures where garnet porphyroblasts may also be present. The quartz and mica are generally accompanied by minor amounts of plagioclase (albite or oligoclase), opaque oxides, tourmaline and apatite. The quartzites are locally calcareous, in which case they contain calcite as evenly scattered microscopic grains or aggregates, or as pods and lenses oriented parallel to the foliation.

Light grey to white, massive quartzite occurs locally within Unit EBQ, but is not common. Where present it comprises intervals ranging up to several metres thick which are enclosed within typical platy quartzites and quartz mica schists.

Coarse-grained quartzite and grit were observed within Unit EBQ, mainly in the vicinity of Deadfall Creek, where they occur as relatively massive beds up to several tens of centimetres thick, intercalated with platy quartzite and phyllite. These coarser grained rocks consist of discrete clasts 1 to 5 millimetres in size, enclosed within a light to dark grey matrix of finer grained quartz and sericite. The clasts are mainly light to dark grey quartz but also include blue quartz and chalky white or grey feldspar.

Pelitic rocks within Unit EBQ range from medium to dark grey and light greenish grey phyllite and fine-grained quartz sericite schist in low-grade exposures, to coarse-grained silvery grey or brown staurolite-garnet-biotite-muscovite-quartz schists in exposures of higher metamorphic grade. These rocks are fairly common as interbeds within platy quartzite, but in most outcrops are distinctly subordinate in quantity to the quartzites.

Limestone, marble, calc-silicate schist and calcareous phyllite, together with chlorite schist of mafic metavolcanic origin, dominate the upper part of Unit EBQ where it is exposed along the north side of the Baldy batholith, between Granite Mountain and the Barriere River, and along the slopes south of Mount McClennan. These rocks are intercalated with quartzite and quartz mica schist typical of Unit EBQ and are overlain by either Unit EBA or Unit EBS (Figure 4). They bear a strong lithologic resemblance to Unit EBG, with which they may be correlative (Figure 7). Chlorite schist, limestone and calcareous metasediments occur locally elsewhere within Unit EBQ, but are not common.

One relatively poorly foliated body of coarse-grained chlorite-quartz-albite-epidote-actinolite schist (with minor biotite and sphene), which is exposed to the southwest of Deadfall Creek, may be of intrusive origin.

The age of Unit EBQ is unknown, other than that it must be older than the mid to late Devonian granitic and volcanic rocks which respectively intrude and overlie it. It is, however, lithologically very similar to Unit EBH, of Early Cambrian and/or older age, with which it is tentatively correlated (Figure 7). This correlation suggests that the mafic metavolcanics, limestone and related rocks which comprise the upper part of Unit EBQ in the vicinity of Mount McClennan and to the northeast of Granite Mountain may be correlative with the lithologically similar Early Cambrian rocks of Unit EBG. Unit EBQ is probably equivalent to map unit 1 of Campbell and Tipper (1971), which outcrops north of the Raft batholith in the vicinity of Mahood Lake. Their map unit 1, comprised largely of quartz mica schist and quartzite, is inferred to be in thrust contact with underlying Fennell Formation rocks, and thus occupies a similar structural position to northwestern EBQ exposures within this study area (Figure 4). Campbell and Tipper (1971) tentatively assigned their map unit 1 to the Kaza or Cariboo Group, suggesting a Hadrynian or Cambrian and later age. These rocks extend northward into the predominantly Hadrynian to Early Paleozoic Snowshoe Formation of Struik's (1985) Barkerville terrane.

UNIT EBS

Unit EBS is a heterogeneous package of rocks dominated by fine to coarse-grained clastic metasediments which are intercalated with carbonate and mafic to felsic volcanic and volcaniclastic horizons. Rocks assigned to this unit occur mainly at the base of the first fault slice, but also locally within the third fault slice where they overlie Unit EBQ (Figures 6 and 7).

Rocks of Unit EBS in the first fault slice occupy a northwest-trending, northeast-dipping belt near the southwestern edge of the map area, between Adams Lake and the Barriere River. A major anticlinal hinge is inferred to occur within the unit such that the southwestern part of the belt is overturned. The overturned limb and the fold's axial trace are truncated to the southeast along a northwest-trending fault which defines most of the southwestern edge of the belt and causes it to thin markedly toward Adams Lake. The base of Unit EBS is not seen in this area. It is overlain, to the northeast, by Units EBL, EBK, EBA and EBF as these units progressively pinch out from Adams Lake to the Barriere River. To the southwest, however, in the core of a medium-scale syncline in the vicinity of Dixon Lake, and along the southwestern edge of the belt in the vicinity of Louis Creek, Unit EBS is stratigraphically overlain by mafic metavolcanic rocks of Unit EBM. Foliated dioritic rocks intrude Unit EBS metasediments at several localities within the belt and may be related to these overlying metavolcanic rocks.

The dominant rock types within Unit EBS are phyllitic sandstone, grit and quartzite comprised of distinct clastic quartz grains within a finer grained, more or less foliated matrix of quartz and sericite. These rocks are generally light to medium shades of grey and green, but locally may be dark grey or brownish grey in colour. In places they are intercalated with horizons of phyllite defining distinct, locally graded beds several centimetres to several tens of centimetres in thickness; elsewhere they comprise intervals many tens of metres thick with little or no intercalated phyllite and generally indistinct bedding contacts. Locally the unit includes horizons of relatively pure, massive, light grey quartzite up to several tens of metres thick. One such horizon (EBSq) can be traced for more than 5 kilometres between Sinmax and Dixon creeks, and similar quartzite outlines a series of folds just to the south, around Forest Lake. Grey to green phyllite, with little or no intercalated coarser grained rock, dominates parts of Unit EBS but does not seem to form mappable belts. One distinctive horizon of medium to dark grey phyllite and siltstone (EBSp) is, however, traceable for about 3 kilometres in the area west of Forest Lake.

The clastic grains in characteristic EBS rocks commonly range up to 5 millimetres in size. They are poorly sorted and generally flattened to some extent within the plane of the phyllitic foliation. The clasts are mainly mono and polycrystalline quartz, but locally include several per cent plagioclase and occasionally minor amounts of microcline and/or perthitic potassium feldspar. Bent and kinked grains of detrital muscovite are evident in very minor amounts in most thin sections examined. The detrital grains generally float in a foliated finer grained matrix of quartz and sericite. Chlorite is present locally, and sporadic carbonate, opaque oxides, apatite and fine carbonaceous material are present in minor quantities.

Somewhat coarser grained quartz-pebble conglomerate, with clasts up to 1.5 centimetres in size, occurs locally within Unit EBS, but seems to be most common beneath Unit EBM along the northeastern side of the belt. Much coarser grained cobble to boulder conglomerate (EBScg), which occurs on Armour Ridge south of Barriere, may be at a similar stratigraphic level where it is repeated on the southwest limb of the Barriere anticline (Figure 5, section D-D′). The conglomerate comprises poorly sorted clasts to several tens of centimetres in size, within a variably foliated, often calcareous matrix ranging from sericite quartz phyllite to granular quartzite. The clasts are mainly quartz and quartzite, but locally include limestone, phyllite and bedded siltstone.

Carbonate (EBSc) occurs as discontinuous but locally prominent beds at several stratigraphic levels within the EBS succession. Most are light to medium grey finely crystalline limestone or marble, although buff to rusty weathering dolostone and chloritic dolostone are also present. The most prominent of these limestone units ranges up to several hundred metres in thickness and can be traced for more than 5 kilometres between Cicero and Sinmax creeks (Plate 7). Another limestone-dolostone horizon forms prominent outcrops on Barriere Mountain; it is apparently repeated 3 kilometres to the southwest, where it can be traced for about 4 kilometres along the southwest limb of the Barriere anticline (Figure 5, section D-D′). These limestone horizons, as well as a limestone lens which occurs at a similar stratigraphic level 3.5 kilometres northwest of Forest Lake, include local lenses

Plate 7. Prominent carbonate unit within Unit EBS, southeast of Forest Lake.

of sandy limestone containing sand-sized quartz grains. Several other carbonate horizons occurring within Unit EBS in the area north of Sinmax Creek were sufficiently large to be portrayed on the geological map. Two of them form prominent bluffy exposures which are conspicuous from the Squaam Bay road; one directly north of the east end of Forest Lake, the other 2.5 kilometres farther east.

A package of green chloritic schist and greenstone derived from mafic volcanic rocks (EBSb) can be traced within Unit EBS for approximately 10 kilometres southeastward from the Barriere River. The unit includes fragmental and amygdaloidal rocks, which locally contain well-defined pillows which are strongly flattened in the plane of schistosity. Rocks within this unit are totally recrystallized and include the mineral assemblages actinolite-chlorite-albite-sphene and epidote-biotite-actinolite-albite-quartz-calcite. The unit is apparently repeated, but less extensively developed, on the southwest limb of the Barriere anticline, where it is represented by outcrops of pillowed greenstone and chlorite schist 2.5 kilometres east of Barriere (Figure 5, section D-D′). Chlorite schists, some of which may derive from mafic volcanic rocks, occur locally elsewhere within Unit EBS, but are not sufficiently extensive to be distinguished on the geological map.

Rusty weathering, light to medium grey phyllite of probable tuffaceous orgin (EBSt) can be traced intermittently for approximately 12 kilometres along the northeastern segment of the Unit EBS belt, from north of Dixon Creek to Sinmax Creek; it continues to the southeast across Sinmax Creek where it outlines a syncline-anticline pair. The phyllite consists mainly of quartz and sericite accompanied by varying proportions of rusty weathering carbonate. In places it contains small broken feldspar crystals and/or lithic fragments to several centimetres in size. Similar rusty phyllite occurs locally on the lower slopes east of Sargent and Louis creeks and may represent this same horizon repeated on the southwest limb of the Barriere anticline. Pyritic sericite-quartz schist (EBSa), locally with chloritoid porphyroblasts, outcrops to the southeast of these exposures (Figure 4); it may be derived from a related felsic volcanic horizon (*see* Chapter 4, Fortuna showing).

Rocks assigned to Unit EBS within the third Eagle Bay fault slice consist mainly of schistose chlorite-sericite grit and sandstone, together with chlorite-sericite-quartz schist and relatively pure quartzite. These rocks are intercalated with minor amounts of dark grey phyllite, dark green chlorite schist of probable mafic volcanic origin, and rare thin horizons of limestone and dolostone. They outcrop on the slopes south of Mount McClennan on the north side of the North Thompson River, and south of the river east of Jones Creek. They are apparently restricted to a single fault block, within which they are underlain by Unit EBQ and overlain by Unit EBP.

The age of Unit EBS is not known. It is presumed to be Early Cambrian and/or younger as it locally lies above Unit EBQ and Middle Devonian and/or older since it lies beneath the Middle Devonian felsic phyllites of Unit EBA. It is lithologically similar to parts of the Lardeau Group in the Kootenay Arc, which is inferred to be Cambro-Ordovician in age (Read and Wheeler, 1976; Read *in* Brown *et al.*, 1981, pages 351-352). It is also similar to Paleozoic grit and associated rocks within the Snowshoe Formation of the Barkerville terrane (Struik, 1985).

UNIT EBL

Unit EBL, comprising limestone and calcareous phyllite, occupies a narrow belt which has been traced 11 kilometres northwestward from the south end of Adams Lake. The limestone is dark or medium grey; it is flaggy with sericite-graphite partings and typically contains knots and lenses of white calcite. It is intercalated with brownish grey or rusty weathering calcareous black phyllite and argillite. Unit EBL is structurally overlain by grey and green-banded schists of Unit EBK. This contact is well exposed on an old logging road just above Adams Lake where it appears to be one of gradual change and conformity. Unit EBL is underlain by grit and quartzite of Unit EBS; this contact is not well exposed, but no major structural or stratigraphic breaks are apparent.

Unit EBL is lithologically identical to the Sicamous Formation as mapped by Jones (1959) in the Vernon map area, and is apparently continuous with Jones' northwesternmost Sicamous outcrops. Inclusion of this unit within a probable pre-Devonian section of the Eagle Bay Assemblage makes the Late Triassic age for the Sicamous Formation proposed by Campbell and Okulitch (1973) and Okulitch (1974, 1979) seem unlikely. It also suggests that rocks, such as Unit EBS, that have been included in the Eagle Bay Formation within Adams Lake and Bonaparte Lake map areas, may correlate with units of the Mount Ida Group within the Vernon map area.

UNIT EBK

Unit EBK consists of calc-silicate schists and skarn; it occurs as a narrow band of rocks which has been traced from the south end of Adams Lake for about 13 kilometres to the northwest. It is underlain by dark grey limestone and calcareous phyllite of Unit EBL or by Unit EBS where Unit EBL pinches out in the northwest. Unit EBK is overlain by sericite quartz schist and orthogneiss of Unit EBA, and includes intercalations of quartzofeldspathic schist that were probably derived from felsic sills related to these overlying rocks.

The most common lithology within Unit EBK is a fine-grained, weakly schistose, distinctly banded rock; medium to dark green bands alternate with light green and/or light grey bands. Individual bands range from 1 millimetre to 1 centimetre in thickness; they are sharply defined but typically display lenticular, interfingering contacts. These rocks consist predominantly of quartz and actinolite, generally accompanied by varying amounts of epidote, calcite, plagioclase, sphene and apatite; muscovite, biotite and opaque oxides may also be present. Light-coloured bands are generally quartz-rich, while darker bands are rich in actinolite, epidote and sphene. In one sample, however, dark bands are actinolite-rich, light bands are epidote-rich, and quartz and calcite are distributed more or less evenly throughout the rock.

Relatively massive, light to medium greenish grey, mottled to vaguely laminated skarn, consisting mainly of actinolite-epidote-sphene-calcite-quartz±garnet or hornblende, is associated with the banded rocks. The skarns commonly include irregular patches of massive dark green rock consisting mainly of phlogopitic mica together with epidote, calcite and sphene. Locally the skarn contains asbestiform intergrowths of epidote and tremolite-actinolite as thin veins. Lenses of pyrite and pyrrhotite containing traces of chalcopyrite are also present locally.

Bands of light grey to greenish grey quartzofeldspathic schists up to 10 metres thick, that are derived from felsic igneous rocks, occur within Unit EBK. The schists typically contain "eyes" of quartz, and less commonly plagioclase, within a fine-grained, weakly to strongly foliated matrix of quartz, feldspar, sericite, epidote and chlorite. Actinolite is present locally; sphene, apatite, zircon and opaque oxides are usually present in accessory amounts. These rocks were derived from quartz feldspar porphyries similar in composition to overlying Unit EBA rocks. They are presumed to be sills related to the overlying rocks, although it is possible that some might be of extrusive origin.

Unit EBK displays a conformable and gradational contact with underlying Unit EBL rocks where the contact is exposed near the Adams Lake shoreline. It was probably derived from calcareous sediments, similar to those of Unit EBL, which underwent varying degrees of skarn alteration during intrusion of felsic sills related to the overlying Devonian volcanic rocks of Unit EBA. Unit EBK is therefore assigned a Devonian and/or older age, since it is not known whether the contact with Unit EBA is conformable or unconformable.

UNIT EBM

Unit EBM consists of massive and pillowed greenstone, chlorite schist, quartzite, phyllite and bedded chert. It is well exposed in a belt which extends southeast from the forestry lookout east of Barriere Mountain to the north slopes overlooking Sinmax Creek, where it overlies quartzite, grit and phyllite of Unit EBS, in the core of a medium-scale, west-verging syncline. It is repeated to the southwest along a narrow belt extending southeast from the south end of Armour Ridge, where it lies structurally beneath Unit EBS on the overturned limb of the Barriere anticline. Along much of this belt it is separated from Unit EBS by a northeast-dipping fault and serpentinite lens; it is structurally underlain by black phyllite and sandstone of Unit EBP between Louis and Cicero creeks.

The major components of Unit EBM are fine-grained, medium to dark green chloritic schist, and green to grey weakly foliated to massive greenstone. In the eastern belt, these mafic metavolcanic rocks are commonly vesicular and/or amygdaloidal (with calcite and/or chalcedonic quartz filling the vesicles); pillows and pillow breccias occur locally. Pillows and amygdules are typically strongly flattened within the plane of the schistosity. The rocks are completely recrystallized and provide little indication of their original mineralogy or texture. They consist mainly of chlorite, sodic plagioclase and calcite, commonly with epidote, magnetite and minor amounts of quartz. Green biotite and/or stilpnomelane occur locally. Medium to coarse-grained greenstone, consisting of clots of chloritic hornblende (?) interspersed with saussuritic plagioclase and minor quartz, is present locally; it is probably of intrusive origin. These rocks are similar to the metadiorite (Unit di) commonly found within the underlying Unit EBS succession.

Intercalated with the mafic metavolcanic rocks of Unit EBM are relatively thin horizons of fine to coarse-grained quartzite and phyllite similar to rocks within underlying Unit EBS. Bedded chert similar to that within the Fennell Formation is also present, but less common. The chert is light to medium green or grey in colour; it occurs as beds 3 to 10 centimetres thick, separated by thin phyllitic partings. Chert beds up to several metres thick were noted within both the eastern and western EBM belts. No bedded chert was found elsewhere in the Eagle Bay Assemblage.

Unit EBM is inferred to be in stratigraphic contact with Unit EBS as the latter unit is intruded by diorite which may be an intrusive equivalent to the overlying EBM mafic volcanics. The quartzite and phyllite which occur within Unit EBM suggest that the contact is conformable. The relationship between Unit EBM and the Devono-Mississippian rocks of Units EBA, EBF and EBP is not known. These rocks lie above Unit EBS on the east limb of the anticline which passes just east of Dixon Lake, while Unit EBM rests above Unit EBS within the synclinal trough to the west (Figure 5, section E-E'). The upper part of the Devono-Mississippian succession, Unit EBP, lies directly beneath (presumably stratigraphically above) Unit EBM on the overturned southwest limb of the Barriere anticline, but the contact was not observed. It may be that Unit EBM is approximately the same age as the Devono-Mississippian package or alternatively, that the Devono-Mississippian package rests unconformably above Units EBS and EBM.

UNIT EBA

Unit EBA is dominated by light grey chlorite-sericite-quartz phyllite and schist derived mainly from felsic to intermediate volcanic and volcaniclastic rocks. Green chlorite schist derived from mafic volcanic rocks is present locally. Bands of dark grey phyllite and siltstone comprise approximately 10 per cent of the unit. Unit EBA is host to numerous polymetallic base and precious metal showings within the map area (*see* Table 1).

Unit EBA occurs within both the first and third fault slices. Within the third fault slice it lies above Unit EBQ and is overlain either by Unit EBF or Unit EBP; locally, however, it is structurally overlain by Unit EBG of the overlying fault slice. It outcrops most extensively in the vicinity of Foghorn and Birk creeks, north and south of the Baldy batholith, where it is several hundred metres thick. It thins markedly to the east, and in the vicinity of Vavenby is generally no more than a few tens of metres thick. Within the first fault slice, Unit EBA comprises part of a northeasterly dipping belt which extends from the Barriere River to the Adams Plateau at the southeast limit of the map area. Within this belt it is underlain by Unit EBS or by the intervening rocks of Unit EBK. It is stratigraphically overlain by Unit EBF in the northwestern part of the belt, but to the southeast lies directly beneath Unit EBG of the second fault slice, below a northeast-dipping thrust fault. Zircons extracted from Unit EBA felsic schists on the east shore of Adams Lake indicate a mid-Devonian age for this part of the unit.

Unit EBA forms prominent bluffs on the slopes northeast of Sinmax Creek and on the shores of Adams Lake. It is also well exposed, although less conspicuously, along the lower reaches of McDougal Creek and along much of Foghorn Creek in the northern part of the map area.

The most abundant and characteristic rock type within the unit is fine-grained, light silvery grey to greenish grey sericite quartz phyllite, grading in places to slightly coarser grained muscovite quartz schist. Chlorite is generally present in amounts subordinate to the sericite, but may be absent. Weathered surfaces are light to medium shades of yellowish brown, reddish brown or grey, but may be dark rusty brown or bright yellow in areas of relatively intense pyrite mineralization. The rocks typically display a very fine and well-developed papery fissility, although more platy varieties, comprising millimetre to centimetre-thick siliceous lenses and layers separated by thin sericite partings, also occur. Roundish "eyes" of clear quartz are commonly present and grains of chalky white feldspar are locally evident. In places the phyllite has a spotted appearance due to the presence of porphyroblasts of rusty brown-weathering siderite, or less commonly chlorite or chloritoid. Thin veins and lenses of quartz or quartz-carbonate often occur parallel to the schistosity. The phyllites are typically quite homogeneous over large intervals and contacts between individual volcanic or volcaniclastic horizons are not commonly evident. Locally the phyllite is coarsely fragmental and probably derived from coarse pyroclastic rocks (Plate 8) although fragmental units are not as common as in overlying Unit EBF. The clasts, comprising sericitic and/or chloritic siliceous lithic fragments, range from less than 1 centimetre to several tens of centimetres in size; they are generally flattened and foliated within the plane of the matrix schistosity.

In thin section phyllite and schist display a relatively fine-grained recrystallized and foliated matrix which may enclose relict grains of quartz and/or feldspar. Quartz and sericite are the dominant matrix constituents; they are commonly accompanied by chlorite, carbonate (calcite and/or siderite) and relatively minor amounts of albite. Relict grains of quartz, and locally feldspar, are common but not ubiquitous, and comprise anywhere from less than 1 per cent up to 60 per cent of the rock. They range from less than 1 millimetre to almost 1 centimetre in size. The quartz grains are typically rounded and display corroded and embayed margins, typical of volcanic quartz phenocrysts (Plate 9). Relict feldspar grains are mainly plagioclase, although sanidine also occurs, but is rare. The plagioclase appears to be mainly albite, although many of the grains are highly altered to sericite and calcite, and their original composition is obscure. Other components of Unit EBA phyllites include small grains of zircon, apatite, tourmaline and rutile. Chloritoid occurs as randomly oriented porphyroblasts at a few localities near McDougal Creek in the northern part of the map area. Pyrite is fairly common, either as small disseminated grains or as large sparsely scattered cubes. It is most common within conspicuous rusty to yellowish weathering lenses of bleached pyrite-sericite-quartz schist. These occur sporadically throughout the unit and range from a few centimetres to tens of metres in thickness. A large-scale version of one of these bleached pyritic zones is locally in excess of 100 metres thick and can be traced for approximately 10 kilometres along the cliffs northeast of Sinmax Creek, between Johnson Creek and Squaam Bay. This unit hosts the Homestake precious and base metal baritic deposit as well as a number of smaller mineral showings. Thin horizons of pyritic cherty rock of possible exhalative origin are also present locally.

Light to medium green chloritic phyllite and schist intervals within Unit EBA are generally similar to the more typical silvery grey phyllites in both composition and texture, but have a higher proportion of chlorite relative to sericite and are usually less quartzose and more feldspathic than their lighter coloured counterparts. Distinctly more mafic, medium to dark green schists consisting of chlorite, albite, epidote and actinolite or green biotite are also present; these have little or no quartz and sericite. A band of dark green fragmental schist 10 metres thick, exposed along lower Foghorn Creek, contains coarse fragments of both dark green chloritic schist and light grey sericite quartz schist.

Metasedimentary intervals of medium to dark grey phyllite, siliceous phyllite, slate and siltstone are present throughout Unit EBA and are estimated to comprise about 10 per cent of the succession. Individual bands range from a few metres to a few tens of metres in thickness. Contacts with adjacent light-coloured sericite quartz phyllite are generally sharp but locally are gradational and indistinct. The dark grey phyllite and siltstone are usually pyritic and may contain concordant lenses of pyritic quartz or quartz and rusty carbonate. These dark metasediments are very similar in appearance and composition to the slate, phyllite and siltstone which characterize Unit EBP.

Medium-grained, light to medium greenish grey quartzofeldspathic orthogneiss of Unit Dgn intrudes Unit EBA in the southern part of the map area, on both sides of Adams Lake. It occurs as a number of sill-like bodies within the central and lower parts of the exposed EBA succession. Similar orthogneiss locally cuts Unit EBA rocks of the third fault slice in the vicinity of Harper Creek, Avery Lake and Reg Christie Creek. In this area, however, orthogneiss is more common within the underlying rocks of Unit EBQ. The orthogneiss is Devonian in age and presumed to be genetically related to the volcanic and volcaniclastic rocks of Unit EBA.

Three zircon separates from Unit EBA metavolcanic rocks on the east shore of Adams Lake yielded lead-uranium points which define a discordia line with an upper concordia intercept of 387 million years (Ma) (Preto, 1981; Preto and Schiarizza, 1985). This indicates a Middle Devonian age for this part of the EBA succession. This Middle Devonian age fits well with geological relationships established within the area, as Unit EBA and the overlying rocks of Unit EBF lie beneath Unit EBP metasediments which contain early and late Mississippian conodonts. Dark grey phyllite and siltstone of Units EBA and EBF are similar to those which characterize Unit EBP, while volcaniclastic rocks intercalated with Unit EBP metasediments are similar to those within Unit EBF. The three units are therefore inferred to comprise, at least in part, a more or less continuous volcanic-sedimentary succession of Middle Devonian to Late Mississippian age.

The contact relationships between Unit EBA and underlying rocks, none of which are dated, are not clear. Within the third fault slice Unit EBA is underlain by Unit EBQ. The contact is thought to be stratigraphic because Unit EBQ is intruded by Devonian orthogneiss and quartz porphyry sills which may be related to the overlying EBA volcanics. The early Cambrian age which is tentatively inferred for Unit EBQ suggests that the contact is an unconformity. Within the

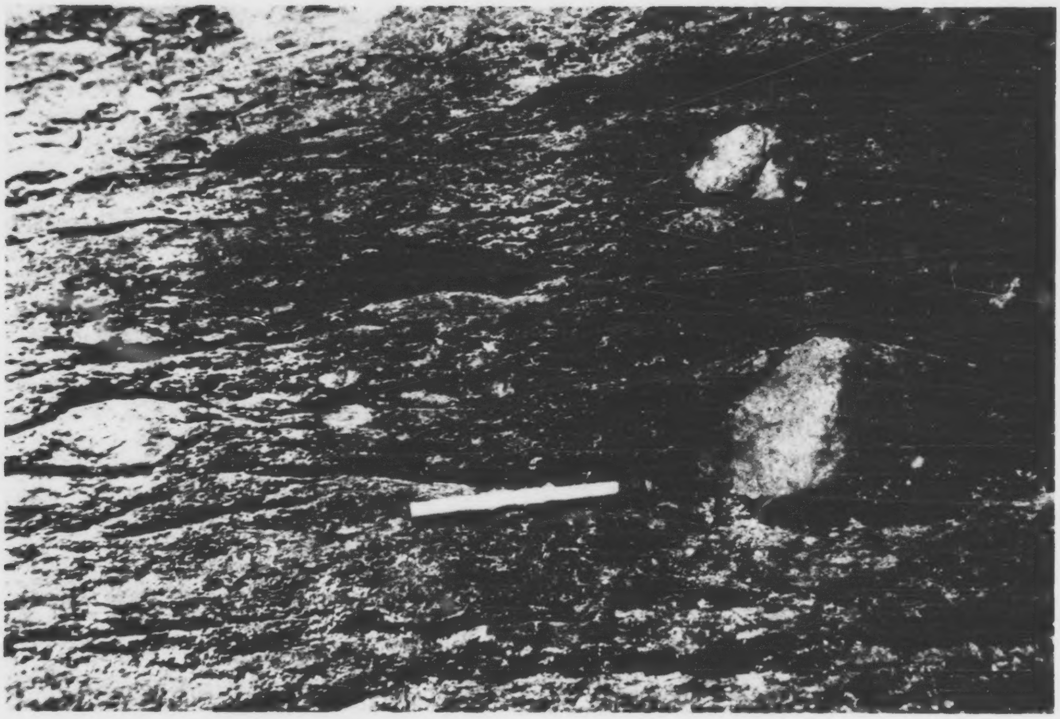

Plate 8. Fragmental sericite quartz schist of Unit EBA, Foghorn Creek.

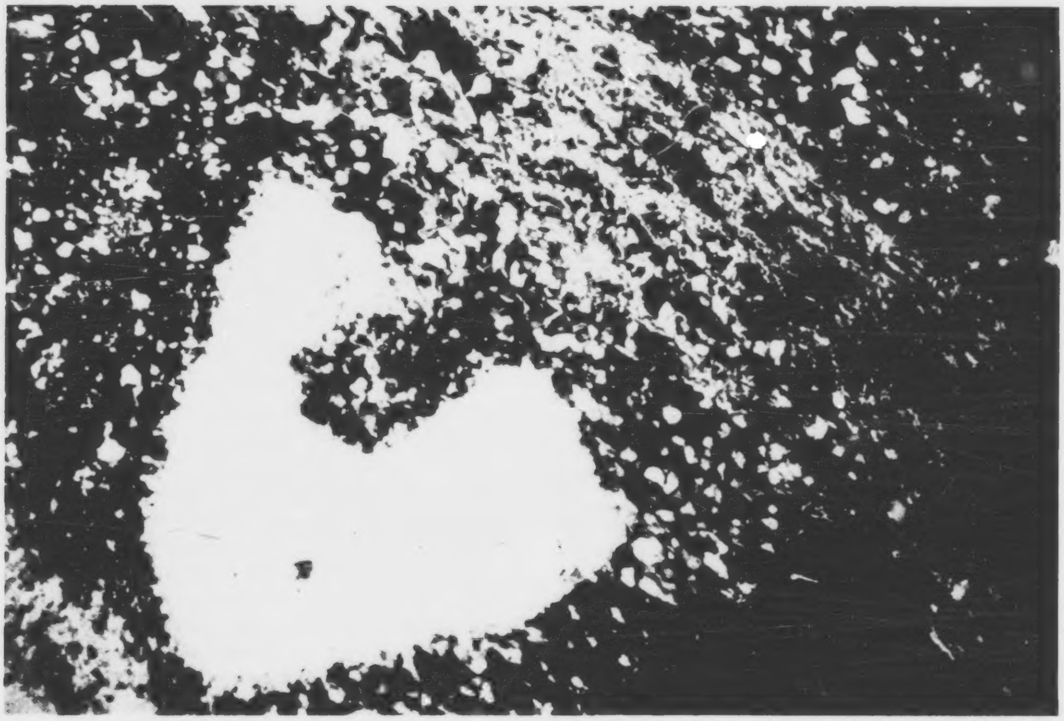

Plate 9. Photomicrograph of Unit EBA chlorite-sericite-quartz schist showing an embayed quartz phenocryst, Birk Creek. Phenocryst is approximately 1 millimetre in diameter.

first fault slice, Unit EBA sits above the clastic metasediments of Unit EBS, but is locally separated from them by Units EBK and EBL. Along the northwest end of the belt, Unit EBA itself pinches out and Unit EBS sits directly beneath Unit EBF. None of the contacts is well exposed and it is not known whether they are conformable, unconformable, or structural. The number of units which pinch out at or near the basal EBA contact (such as Units EBL, EBK and EBM) suggests that the relationship may be unconformable. On the other hand, the presence of felsic to intermediate volcanic and volcaniclastic rocks within the upper part of Unit EBS (for example, Units EBSa and EBSt) is suggestive of a gradation into overlying EBA felsic volcanic rocks.

UNIT EBF

Rocks assigned to Unit EBF consist mainly of gritty and fragmental feldspathic rocks which were derived from intermediate tuff and volcanic breccia. North of the Baldy batholith they overlie Unit EBA in the third Eagle Bay fault slice, and are locally in direct contact with the Fennell Formation across the thrust fault at the base of the fault slice (Figure 5, section A-A′). Trachytic rocks, which host the Rexspar uranium-fluorine mineralization along Foghorn Creek, are included within the unit (EBFt). Unit EBF also occurs within the lowest Eagle Bay fault slice where it occupies a northeast-dipping belt extending from Barriere River to just west of Adams Lake. They again overlie Unit EBA along most of this belt but in the northern part, where Unit EBA is absent, they sit directly above Unit EBS. Unit EBF is itself overlain by black phyllite and sandstone of Unit EBP along the northern segment of the belt, but to the south is directly overlain by Unit EBG across a northeast-dipping thrust fault. Unit EBF is assigned a Devonian and/or Mississippian age, based on its stratigraphic position between the Devonian felsic metavolcanic rocks of Unit EBA and the Mississippian clastic metasediments of Unit EBP. Southwest of Johnson Lake it hosts the recently discovered Rea massive sulphide occurrence.

Unit EBF comprises a distinctive and in places monotonous assemblage of gritty and/or fragmental feldspathic phyllites, schists, and similar but poorly foliated rocks (Plates 10 and 11). Mesoscopically conspicuous grains of chalky white feldspar are ubiquitous and are the most characteristic component of the rocks. The feldspar grains are typically 1 to 5 millimetres in diameter and are locally accompanied by grains of quartz, mafic minerals and lithic fragments of similar size. These generally comprise from 20 to 60 per cent of the rock and are enclosed within a matrix of more or less foliated fine-grained sericite, chlorite, quartz and feldspar. Siderite and/or calcite are typically present as porphyroblastic grains and clots which often make up 5 to 20 per cent of the rock. Large lithic clasts, up to several tens of centimetres in size, are conspicuous at a number of places within the unit, but are most common in the first fault slice, in the vicinity of Johnson Creek and along the cliffs overlooking Sinmax Creek (Plate 10).

The rocks of Unit EBF range in colour from light grey to medium or dark shades of grey and green; the colour variation is largely a reflection of the relative proportions of sericite and chlorite in the matrix. They are commonly rusty weathering due to the presence of siderite and/or ankerite. Bedding or compositional layering is not commonly observed; the synmetamorphic cleavage is the dominant fabric element present. The cleavage is generally moderately to strongly developed, but in some exposures may be barely discernible. Even where relatively strongly foliated, Unit EBF rocks typically have an imperfect and irregular splitting habit, due to the abundant mineral and rock fragments and the relatively low percentage of phyllosilicate grains.

The discrete feldspar grains which characterize rocks of this unit are mainly plagioclase which displays varying degrees of saussuritic alteration. It is dominantly albite although more calcic varieties are preserved locally. The plagioclase is accompanied by sanidine or by a stringy perthitic feldspar in a few thin sections examined. The feldspars may display rectangular or lath-shaped outlines, although grains with rounded or broken edges are more common. In some localities feldspar grains are broken apart and boudinaged within the plane of the metamorphic foliation.

The feldspars are generally accompanied by grains of monocrystalline and polycrystalline quartz, lithic fragments and less commonly, by relict grains of hornblende or biotite. Apatite and zircon are additional relict components which are invariably evident in thin section. The lithic grains are generally sericitic quartzofeldspathic rocks of probable volcanic orgin. Likewise, coarse lithic fragments within fragmental portions of the unit are generally of gritty feldspathic phyllite and sericitic quartzofeldspathic rock similar in composition to their matrix. The coarse fragments are generally flattened within the plane of the metamorphic foliation and usually display a foliation continuous with that of the matrix.

The matrix of a typical rock consists of a fine-grained indistinct mass of quartz, feldspar, and poorly to well-oriented phyllosilicate grains. Sericite is invariably present and usually predominates over chlorite. Medium to dark green varieties, however, contain chlorite as the dominant phyllosilicate and often contain minor amounts of epidote and sphene. Carbonate minerals, dominantly siderite, occur as clots and lenses and locally as idioblastic porphyroblasts. Chloritoid porphyroblasts were noted at a few localities north of Foghorn Mountain.

Most of Unit EBF was clearly derived from a series of crystal-lithic tuffs and volcanic breccias. Epiclastic as well as pyroclastic varieties may be present and a minor component was derived from porphyritic flows. The composition probably varies from andesitic to rhyolitic, with dacitic compositions predominating. The presence of trachyte within equivalent rocks at the Rexspar deposit and of alkali basalt at the Rea massive sulphide deposit indicates that alkalic rocks are also present within Unit EBF; these may be more widespread than has been recognized.

A distinctive unit of light grey, massive cherty siliceous rock (EBFq) can be traced for about 1.5 kilometres within Unit EBF just south of Foghorn Mountain. This northeast-trending body appears to comprise a conformable lens within tuffs of Unit EBF, although its contacts were not observed and it does not display bedding features or any other primary structures. It consists of massive, very fine-grained "cherty" quartz containing a few small rusted-out pyrite (?) grains; veins of white quartz are common. Thin section examination

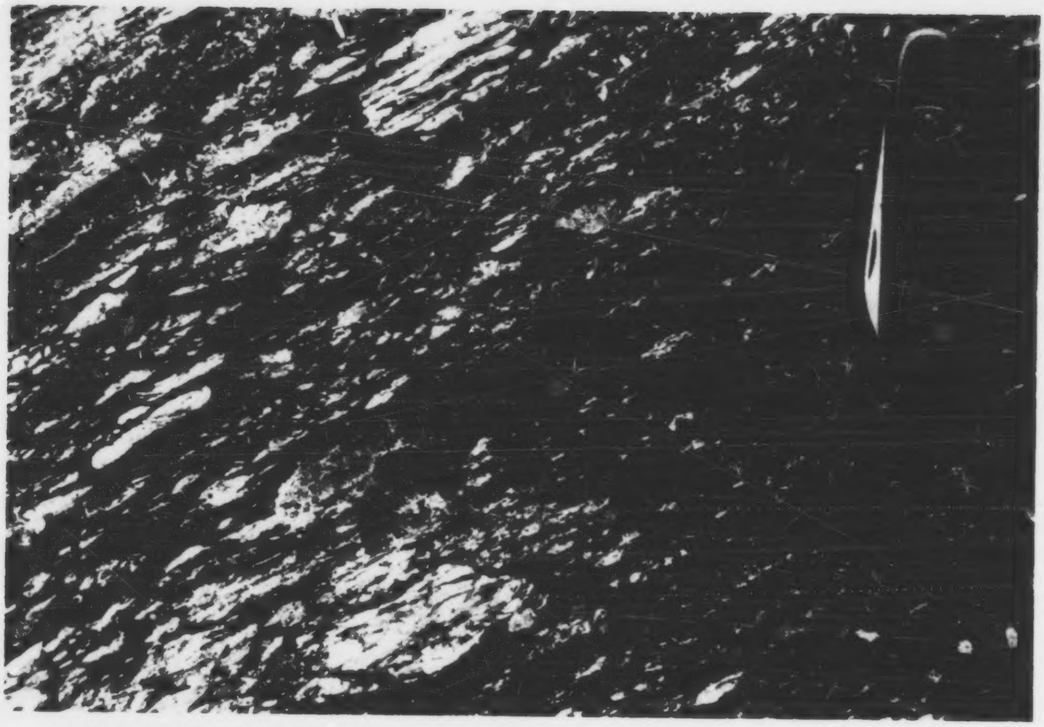

Plate 10. Fragmental sericite chlorite schist of Unit EBF, in an outcrop on the slope northeast of Sinmax Creek.

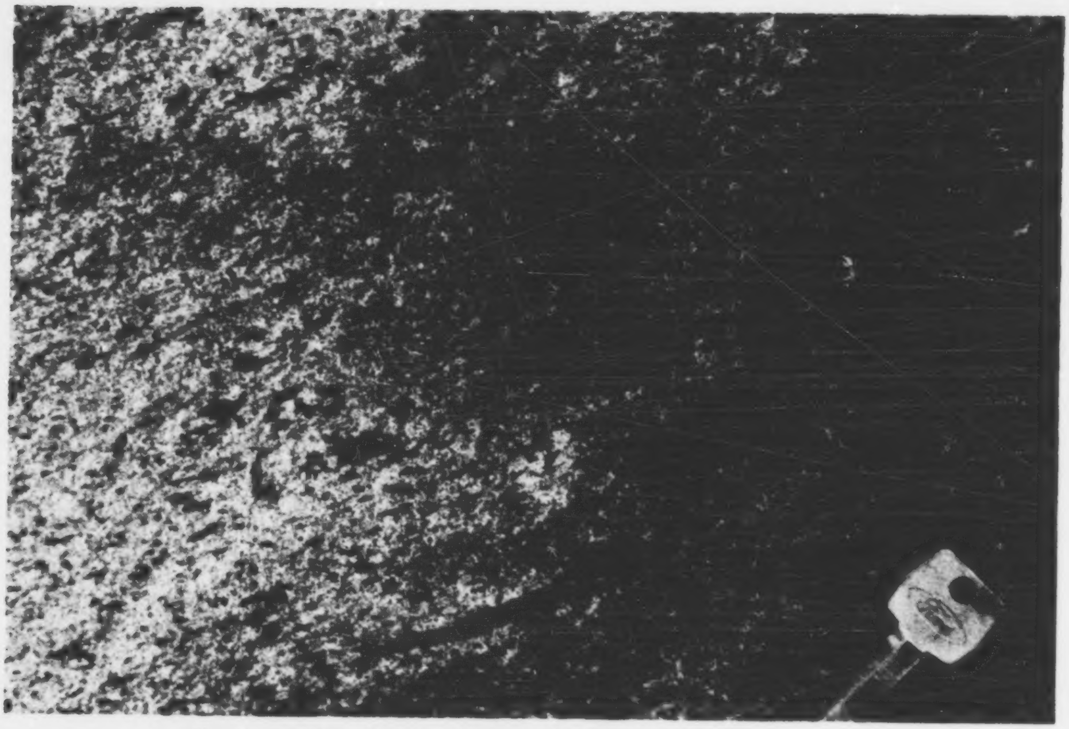

Plate 11. Hornblende-feldspar-quartz crystal-lithic tuff of Unit EBF, east of Lute Creek.

reveals only small quartz grains, 0.06 millimetre in diameter, and very minor amounts of sericite and opaque grains. The origin of this unit is uncertain; it is perhaps derived from a siliceous exhalative deposit.

Rocks assigned to Unit EBFt comprise an intrusive/extrusive package of trachytic, dacitic and rhyolitic rocks which host the uranium-fluorine mineralization at the Rexspar and Bullion properties in the vicinity of Foghorn and Lute creeks (Preto, 1978a, 1978b). The dominant rock type is massive to moderately foliated feldspar porphyry containing megacrysts of albite and potassium feldspar; this occurs with coarse fragmental rocks containing mainly clasts of feldspar porphyry, and sericite-feldspar-quartz schist. These rocks were previously included within Unit EBA (Schiarizza and Preto, 1984); extension of mapping to the east of Foghorn Creek (Schiarizza, 1986a, 1986b) now suggests that they lie above Unit EBA and are laterally equivalent to Unit EBF.

Dark grey phyllite, siltstone and grit were noted within Unit EBF at only a few places in the vicinity of Johnson Creek. Similar rocks are much more common in the underlying Unit EBA and are the dominant lithology in overlying Unit EBP.

North of the Baldy batholith, Unit EBF overlies Unit EBA within the third Eagle Bay fault slice and is locally in fault contact with adjacent steeply dipping rocks of the Fennell Formation (Figure 5, section A-A′; *see also* Schiarizza, 1983, sections B, C, D and E). Within this area there is no direct evidence for the age of any of the exposed Eagle Bay units. Within the first fault slice, the northeasterly dipping belt of Unit EBF rocks between Barriere River and Adams Lake is also underlain over most of its length by Unit EBA, which immediately to the southeast (within the same belt) is dated as Middle Devonian. Unit EBF is overlain along most of this belt by Unit EBP, which is dated as Mississippian. Unit EBF is therefore confidently assigned a Devonian and/or Mississippian age, and on the whole, the northeasterly dipping belt comprising Units EBA, EBF and EBP faces to the northeast and is right-way-up.

In the area southeast of Johnson Creek, Unit EBF comprises a relatively thick wedge which is structurally overlain by Unit EBG and which pinches out rather abruptly to the southeast, where Unit EBG structurally overlies Unit EBA. Top determinations and bedding/cleavage relationships at the Rea showing indicate that rocks along the northeastern part of this wedge are overturned (White, 1985). A synclinal hinge must therefore be present between the overturned outcrops at Rea and Unit EBF rocks across strike to the southwest, which are assumed to be right-way-up due to their regionally correct position structurally and stratigraphically above Unit EBA. Dark grey argillites and coarse wackes mapped 1 kilometre southwest of the Rea deposit (White, 1985) may represent Unit EBP rocks in the core of this syncline. Unit EBG rocks (presumably right-way-up) to the northwest of Rea are separated from the overturned EBF beds by a northeast-dipping thrust fault. The underlying overturned syncline may be related to the thrusting, and the abrupt pinch out of Unit EBF to the southeast may be due to truncation along the overlying thrust fault.

UNIT EBP

Unit EBP, of Mississippian age, is the youngest unit of the Eagle Bay Assemblage exposed within the study area. It is comprised mainly of dark grey slate, phyllite and siltstone, together with sandstone, granule to pebble conglomerate, limestone, dolostone and intermediate to felsic volcaniclastic rocks. The unit occurs within the first and third Eagle Bay fault slices (Figure 7). Within the first fault slice it outcrops most extensively north of the Barriere River fault where it is in contact with the Fennell Formation in the area south of the Baldy batholith, and within a small fault block immediately south of Clearwater. It also outcrops within a belt south of the Barriere River fault, from North Barriere River to Johnson Creek, and along the southwestern edge of the map area northeast of Fadear Creek. The unit is not well exposed in any of these areas, although reasonably good exposures are found locally along Russell Creek just south of Clearwater, along Sprague Creek east of North Barriere River, and along Alex Creek in the belt south of the Barriere River fault. Unit EBP rocks of the third fault slice outcrop within several fault blocks in the vicinity of Vavenby. Good exposures in this area are mainly in the lower reaches of Jones and Avery creeks.

Slate, phyllite and siltstone are the most abundant rock types within Unit EBP. These rocks are typically dark grey to black in colour, although light greenish grey phyllite is present locally. Siltstone may be somewhat lighter in colour than the associated slaty rocks and, in places, has a greenish or reddish cast. Cubes of pyrite and/or siderite or ankerite porphyroblasts are commonly present and may cause the rocks to become rusty; elsewhere the rocks are medium to dark grey on weathered surfaces. Siltstone is generally subordinate to slate or phyllite and occurs as horizons ranging up to a few centimetres in thickness. These may comprise persistent tabular layers (on the scale of an individual outcrop) or they may be markedly lenticular in nature. Rare grading, small-scale channels, flame structures and vague crossbedding were observed within the siltstone/slate sequences.

Slate and phyllite typically display a well-defined papery splitting habit; commonly, however, the slaty cleavage is cut by a strongly developed crenulation cleavage. The slaty rocks consist mainly of a fine-grained (0.04 millimetre), well-foliated intergrowth of quartz, sericite and chlorite. Trains of fine, dark carbonaceous material may also be present; grains of tourmaline, apatite, plagioclase and zircon are also rarely evident. The coarser grained, less fissile siltstone horizons are similar in composition, but generally display relict clastic textures.

Approximately 30 per cent of the Unit EBP exposures contain horizons of sandstone and/or granule to pebble conglomerate, in addition to slate and siltstone. These coarser grained rocks occur in groups of beds intercalated with slate and phyllite over intervals of several tens of metres or more. They comprise mainly fine to coarse-grained sandstone which occurs in beds ranging from several centimetres to more than 1 metre thick (Plate 12). In general, the thicker beds are coarser grained and often include granule-size clasts. The sandstone beds are commonly graded and rare channels, ripups and sole markings were observed at their bases. These features suggest that much of the sandstone was deposited by turbidity currents (Bouma, 1962; Walker, 1979) although only the A-E divisions of the classic Bouma sequence are recognized.

The metasandstones of Unit EBP were derived mainly from moderately to poorly sorted quartz-rich wackes. Somewhat flattened grains of monocrystalline and polycrystalline quartz, together with a much smaller amount of chert, plagioclase, lithic grains, and accessory muscovite, tourmaline and zircon, occur within a fine-grained recrystallized and foliated matrix. The matrix typically comprises from 10 to 40 per cent of the rock and consists mainly of quartz, sericite and chlorite; carbonate, opaque oxides and pyrite are minor constituents which may be intergrown with the matrix minerals or occur as relatively large porphyroblasts. The lithic component of the sandstones is largely fine-grained slate and siltstone, possibly derived from underlying beds, but also includes sericitic quartzofeldspathic rock, muscovitic quartzite and graphitic muscovite quartz phyllite or schist. Foliation within the lithic fragments is, in most cases, continuous with that of the matrix. Rarely, however, lithic grains display a discordant foliation which predates the matrix cleavage. Detrital muscovite grains are invariably present in accessory amounts within the sandstone; these grains are much coarser than the fine-grained foliated sericite of the matrix and are often bent and fractured.

Quartz-pebble conglomerate was noted rarely within Unit EBP and is similar in composition to the finer grained sandstone and granule conglomerate with which it is associated. Clasts range up to 2 centimetres in size and are set within a dark grey silty or sandy phyllitic matrix. At one locality, east of Peavine Creek, quartz-pebble conglomerate and grit interfinger with schistose chlorite sericite dolostone and locally contain blocks of dolostone to several tens of centimetres in size. Chert-pebble conglomerate was noted in a single exposure on the lower course of Russell Creek, just south of Clearwater. This rock consists of clasts of light to medium grey or green chert and dark grey cherty argillite within a fine-grained matrix of grey-green siliceous phyllite. The clasts are flattened within the plane of the phyllitic cleavage, with length to width ratios of approximately 4:1. They average approximately 5 centimetres in size, but range up to 20 centimetres in longest dimension. The conglomerate apparently comprises a lens or layer only a few metres thick, enclosed within dark grey phyllite; contacts with adjacent rocks are poorly exposed.

Bands of rusty weathering light to medium greenish grey metatuff and metavolcanic breccia, similar to those in Unit EBF, are intercalated with phyllite and siltstone of Unit EBP at a number of places within the area. These metavolcanic layers are typically a few metres or less in thickness and most cannot be traced for any substantial distance. One body, however, is extensive enough to be mapped as a separate unit (EBPv) where it outcrops west of North Barriere Lake between Slate and Birk creeks (Figure 4).

Plate 12. Intercalated slate and sandstone of Unit EBP, Birk Creek area. The base of a thick grit bed occurs in the upper part of the photograph.

Medium to dark grey crystalline limestone, containing small detrital quartz grains, crinoid ossicles, coral fragments and other fossil remains, outcrops as a thin lens adjacent to the Fennell Formation 5 kilometres south of the Baldy batholith, and as two separate lenses 1.5 kilometres south-southwest of the junction of the North and East Barriere rivers. The individual limestone lenses are several metres or more in thickness and are intercalated with typical dark grey phyllite of Unit EBP. The northern lens contains Early Mississippian conodonts, while three separate collections from the two lenses south of the Barriere River contain Late Mississippian conodonts (Appendix 1). A small outcrop of similar, but apparently unfossiliferous, limestone was noted within the belt of Unit EBP rocks northwest of Fadear Creek, and a fault-brecciated and highly recrystallized limestone lens abuts the Baldy batholith just east of the Fennell Formation.

Pale greenish grey schistose chlorite sericite dolostone was noted within Unit EBP only within the third Eagle Bay fault slice. It outcrops along Avery Creek and to a lesser extent along Jones Creek and on the lower slopes of the North Thompson River valley east of Peavine Creek. The dolostone is intercalated with dark grey phyllite, granule to pebble conglomerate and rarely, thin lenses of dark grey limestone. Exposures along Avery Creek indicate that the dolostone locally occurs over intervals that are many tens of metres thick.

Unit EBP rocks exposed in the Vavenby area occur at the top of the third Eagle Bay fault slice. Within this area, which is transected by a number of late, northerly trending faults, the unit is generally thin; it is gradationally underlain by Unit EBA and structurally overlain by Unit EBG of the overlying fault slice. However, within one fault block which is drained by Jones Creek on the south side of the North Thompson River and by Crossing Creek to the north, Unit EBP is substantially thicker and is underlain by schistose grit and related rocks of Unit EBS. The abrupt change in Eagle Bay stratigraphy across the bounding faults suggests that they may follow the loci of earlier faults which were active during deposition of the Devono-Mississippian section of the Eagle Bay succession.

Unit EBP rocks of the first fault slice outcrop both north and south of the Barriere River fault. North of the fault they occupy the hinge zone of the synmetamorphic west-verging Slate Creek anticline. Flat-lying EBP strata on the fold's east limb are right-way-up and are structurally overlain by rocks of the third fault slice across an east-dipping thrust fault. Steeply dipping EBP strata on the fold's west limb face west toward the adjacent Fennell Formation which also dips steeply, faces west, and comprises a continuation of the steep forelimb of the anticline (Figure 5, section C-C′). The contact between the Fennell Formation and Unit EBP is, however, a fault which juxtaposed the Fennell Formation above Unit EBP prior to formation of the synmetamorphic westerly verging fold. Evidence for this fault is provided by the lack of feeder sills of Fennell-like composition within the underlying EBP rocks; by a truncation of Fennell units, including a gabbroic sill, along the contact; and by the presence of rocks within the Fennell succession which are older than the underlying rocks of Unit EBP. The contact is not well exposed but can be closely inferred in the vicinity of the Enargite lead-zinc showing, and again 3 kilometres north of the showing. In these areas the contact apparently occupies a narrow zone of brecciated rock comprising fragments of chert, cherty argillite and siltstone within a matrix of medium grey siliceous argillite. A weak foliation in these brecciated rocks is parallel to and presumably equivalent to the synmetamorphic slaty cleavage in adjacent rocks of Unit EBP and the Fennell Formation.

The easterly dipping belt of Unit EBP rocks which occurs south of the Barriere River fault between North Barriere River and Johnson Creek is stratigraphically underlain by Unit EBF and structurally overlain by Unit EBG across an east-dipping thrust fault. This belt is, in a general sense, right-way-up and comprises part of the northeastern limb of the Barriere anticline (Figure 4, section D-D′). Local indications of overturning, as well as the anomalous outcrop thickness of the unit between South Barriere Lake and Alex Creek (Figure 4, section E-E′), suggest that the unit contains considerable internal folding.

The belt of Unit EBP rocks exposed along the southwest edge of the map area dips moderately to steeply to the northeast and is structurally overlain by chloritic schist and greenstone of Unit EBM. These rocks were included within the Sicamous Formation by Okulitch (1979) and assigned a Late Triassic age based on correlation with fossiliferous strata that crop out east of Vernon (Okutlich and Cameron, 1976). They are herein included within the Eagle Bay Assemblage and inferred to be Mississippian in age, based on their lithologic similarity (including the presence of coarse sandstone and grit) to Unit EBP strata to the north and northeast, and on their association with rocks assigned to Unit EBM. Rocks within this belt are inferred to be overturned and to occupy the faulted southwestern limb of the southwest-verging Barriere anticline (*see* Chapter 3). No top determinations were made within this belt, but bedding/cleavage relationships support the interpretation that the strata are overturned. Sheared augite porphyry breccia ($\mathrm{TRJ_v}$), which occurs within these Unit EBP metasediments near the confluence of Fadear and Louis creeks, is inferred to be a fault sliver of Mesozoic rock bounded by splays from the Louis Creek fault.

EAGLE BAY CORRELATIONS

The Eagle Bay Assemblage may be divided into three packages, based on the ages and apparent stratigraphic relationships of its constituent units (Figure 8). The oldest package comprises the Lower Cambrian archaeocyathid-bearing Tshinakin limestone and associated mafic metavolcanics of Unit EBG, along with underlying quartzite and quartzose schist of Unit EBH. It tentatively includes the correlative (?) rocks of Unit EBQ, which comprises a similar sequence of quartzite and schist overlain locally by carbonate and mafic metavolcanics. The middle package comprises the grit-dominated clastic metasediments and associated carbonate and metavolcanic rocks of Unit EBS, together with locally overlying Units EBL, EBK and EBM. Rocks of the middle package are undated, but appear to lie stratigraphically between the upper and lower packages. The upper Eagle Bay package comprises Devono-Mississippian felsic to intermediate (and locally mafic) metavolcanic rocks and fine to coarse-grained clastic metasediments of Units EBA, EBF and EBP. These rocks sit above various units of the middle and lower packages, and may be separated from underlying rocks by a significant unconformity.

The lower and middle packages of the Eagle Bay Assemblage correlate readily with parts of the Kootenay Arc stratigraphy exposed on the east side of the Shuswap Complex (Figure 8). The key to this correlation is the Tshinakin limestone member of Unit EBG, which is equivalent to the archaeocyathid-bearing Badshot Formation, a prominent carbonate marker within the arc (Wheeler, 1963; Fyles, 1964; Read and Wheeler, 1976). The Badshot Formation is underlain by the quartzite-dominated Hamill Group, which is correlative with Units EBH and EBQ of the Eagle Bay Assemblage. Still older rocks, equivalent to the Hadrynian Horsethief Creek Group of the Kootenay Arc, may also be present in these units. Siliceous phyllite, quartzite and carbonate of Unit EBGs, which occur locally beneath the Tshinakin limestone (Figure 9), are lithologically similar to, and potentially correlative with, the Mohican Formation at the top of the Hamill Group. Mafic volcanic rocks, which dominate Unit EBG, are not nearly so voluminous at this stratigraphic level within the Kootenay Arc, but do occur locally within the Mohican Formation (Wheeler, 1963; Read and Wheeler, 1976; Höy, 1979). The Lardeau Group, consisting largely of phyllite and grit together with mafic volcanics and limestone, lies above the Badshot Formation in the Kootenay Arc and is broadly correlative with the lithologically similar middle package of the Eagle Bay Assemblage, comprising Units EBS, along with EBL, EBK and (?) EBM.

The upper Eagle Bay package is in part the same age as the Mississippian Milford Group of the Kootenay Arc, but is lithologically dissimilar. The Milford Group consists mainly of limestone, sandstone and phyllite together with local intercalations of chert and mafic volcanic rocks; it sits unconformably above the Lardeau Group and locally includes a basal conglomerate that contains previously foliated clasts derived from underlying Lardeau Group metasediments (Read and Wheeler, 1976).

The Eagle Bay Assemblage passes northwestward into a belt of rocks mapped as Snowshoe Formation in the Quesnel Lake area (Campbell, 1978). Struik (1985, 1986) assigns the Snowshoe Formation to Barkerville terrane in the Barkerville–Cariboo River area, and correlates it with Eagle Bay and Kootenay Arc rocks. The correlation is based mainly on lithologic similarities of the three assemblages, particularly the presence of Paleozoic grit and volcanic rocks which are uncommon in homotaxial rocks to the east. Within Barkerville terrane, the lower part of the Downey succession, comprising carbonate and metabasalt intercalated with pelitic and quartzose metasediments (Struik, 1985, 1986), may correlate with the distinctive Lower Cambrian limestone and mafic volcanic division (Unit EBG) of the Eagle Bay Assemblage (L.C. Struik, personal communication, 1986). Overlying and underlying rocks are mainly clastic metasediments which may, in part, be equivalent to Unit EBS, and Units EBH and EBQ respectively. Rocks equivalent to the Devono-Mississippian package of the Eagle Bay Assemblage are not recognized in Barkerville terrane, although undated black pelite and siltite at the top of the Snowshoe Formation (Hardscrabble Unit of Struik, 1986) may correlate with Unit EBP (L.C. Struik, personal communication, 1986).

The Devono-Mississippian rocks comprising the upper Eagle Bay package, although not represented in the Kootenay Arc or Barkerville terrane, are very similar to Devono-Mississippian rocks found elsewhere in the Omineca Belt, in the Yukon Territory (Templeman-Kluit *et al.*, 1976; Gordey *et al.*, 1982a), northern British Columbia (Taylor *et al.*, 1979; Gabrielse and Mansey, 1980; Gordey *et al.*, 1982b) and east central British Columbia (Struik, 1981, 1985, 1986). In northern British Columbia and Yukon these rocks comprise the Earn Group and equivalent rocks informally referred to as the "black clastic" unit. The equivalent rocks in south central British Columbia comprise the Late Devonian to Early Mississippian Guyet Formation and associated rocks of the Black Stuart Formation; these rocks occur in the upper part of Struik's (1985, 1986) Cariboo terrane which is in thrust contact with Barkerville terrane to the west. The Earn Group and equivalent rocks consist mainly of black slate intercalated with chert-quartz sandstone, grit and conglomerate. Locally the succession includes a thick sequence of submarine felsic volcanic flows and tuffs (Templeman-Kluit *et al.*, 1976; Gordey, 1979; Mortensen, 1982). The Earn Group lies unconformably above platformal carbonates, or their basinal equivalents, of the North American miogeocline where it was deposited during a period of subsidence and block faulting related to extension in the outer miogeocline (Gordey, 1979; Templeman-Kluit, 1979). The associated felsic volcanic flows and tuffs which occur in Yukon comprise trachytes and rhyolites which Mortensen (1982) assigns to a peralkaline suite generated in an extensional tectonic setting.

The Devono-Mississippian succession of the Eagle Bay Assemblage resembles age-equivalent Earn Group rocks in lithology (specifically Unit EBP clastic metasediments), in its apparent unconformable relationship to underlying units, and in the presence of mainly felsic and intermediate volcanic rocks. The volcanic rocks of Unit EBF in particular resemble those associated with the Earn Group as they include trachytic rocks (EBFt) at the Rexspar uranium-fluorine deposit and alkali basalts at the Rea massive sulphide deposit (Höy, 1987 and personal communication) which suggest extrusion in a rift environment. The base of the Devono-Mississippian package, however, comprises felsic to intermediate metavolcanic rocks of Unit EBA which, in the vicinity of the Homestake deposit, were derived from calc-alkaline andesite to rhyolite (Höy, 1987 and personal communication). These (Unit EBA) volcanics, together with related granitic intrusive rocks of Unit Dgn, were likely generated in a volcanic arc environment. The Devono-Mississippian part of the Eagle Bay Assemblage may therefore record calc-alkaline volcanism and related plutonism (Units EBA and Dgn) within a continental margin (?) volcanic arc which was subsequently rifted and became the locus of extension-related alkaline volcanism (Unit EBF) and clastic sedimentation (Unit EBP) (T. Höy, personal communication, 1987). This extension may have been related to the early stages of extension and ocean-floor volcanism in the Fennell succession to the west.

FENNELL FORMATION

INTRODUCTION

The Fennell Formation was defined by Uglow (1922) to include fine to medium-grained greenstone and associated gabbro and bedded chert which he mapped along the east side of the North Thompson River valley between Barriere River and Joseph Creek. Chlorite schist and greenstone which outcrop at a number of localities south of Barriere were also included within the formation, but are presently assigned to the Harper Ranch Group of Quesnel terrane. Uglow recognized pillow structures within Fennell Formation greenstone and concluded that most of the formation was of submarine volcanic origin. Walker (1931) concluded that greenstone farther north, in the Clearwater area, was dominantly of intrusive origin and he referred to these rocks as the Fennell batholith. Included metasediments (mainly chert) were inferred to be large remnants of intruded country rock.

Campbell and Tipper (1971) established the outcrop extent of the Fennell Formation from the Barriere River to 52 degrees north latitude, as shown in Figure 3. This includes both Walker's (1931) Fennell batholith and most of the Fennell Formation originally defined by Uglow (1922). They noted a crude stratigraphic division of the formation (but did not map it) with pillowed greenstone predominant to the west, while sedimentary rocks and intrusive phases of the greenstone were mainly restricted to the eastern exposures. They concluded that major units within the formation dip to the west and that the rocks become progressively younger in that direction. Based on close lithologic resemblance, Campbell and Tipper correlated the Fennell Formation with the Antler Formation of the Slide Mountain Group, which outcrops 150 kilometres to the north in the Cariboo River area. They also suggested that the Fennell Formation might be correlative with Tsalkom Formation greenstone which comprises part of the Mount Ida Group in Vernon map area to the southeast. A tentative Mississippian and/or later age was assigned to the Fennell Formation based on its correlation with the Antler Formation.

Within the map area, the Fennell Formation outcrops between the Raft batholith and the Barriere River fault, where it comprises a steeply dipping, west-facing assemblage on the forelimb of the Slate Creek anticline, a major west-verging fold. The formation has been divided into two major units. The structurally lower (eastern) division comprises a heterogeneous assemblage of bedded chert, gabbro, diabase, pillowed basalt, clastic metasediments (in places associated with minor amounts of limestone and metatuff), quartz-feldspar-porphyry rhyolite and intraformational conglomerate. The upper (western) division consists almost entirely of pillowed and massive basalt, together with minor amounts of bedded chert and gabbro. Top indicators throughout the succession are consistently to the west, but the distribution of dated units indicates that the Fennell Formation comprises an imbricated assemblage and not a simple stratigraphic succession. This imbrication presumably occurred in conjunction with emplacement of the entire Fennell mass over Unit EBP of the Eagle Bay Assemblage. Simple paleogeographic considerations suggest that this structural stacking resulted from easterly directed thrusting from an outboard oceanic environment toward the western margin of the North American continent. Both internal imbrication of the Fennell Formation and its emplacement over Unit EBP clearly predated the synmetamorphic folding event during which the imbricated Fennell Formation attained its present position on the steep forelimb of the Slate Creek anticline (Chapter 3).

Conodonts extracted from bedded chert within the lower division of the Fennell Formation range in age from Early Mississippian to Middle Permian (Appendix 1), while zircons extracted from a quartz feldspar porphyry unit within the division have yielded a Devonian uranium-lead age. The distribution of these dated horizons requires that the lower division of the formation comprises at least three and locally four fault slices (Figure 10). The faults separating these slices have been mapped out, but in places their positioning is poorly constrained by age and lithologic controls; age control is not sufficient to preclude the presence of additional imbrication within the established fault slices.

Only two age dates are available for the lithologically monotonous upper structural division of the Fennell Formation. Conodonts from a small chert lens, intercalated with pillowed basalt near the southern end of the study area, are of Middle Permian age, while Early (?) Pennsylvanian conodonts were extracted from a more persistent horizon of bedded chert 30 kilometres to the north near Hallamore Lake. The two divisions are therefore at least in part the same age, and are inferred to be separated by a thrust fault similar in nature and age to the imbricate thrusts within the lower division, and to the thrust which separates the Fennell Formation from Unit EBP. It is also possible that the upper structural division of the Fennell Formation is internally imbricated in the same way as the lower structural division. This has not been demonstrated, however, because of its uniform lithology and the lack of age control within it.

BASALT, DIABASE, GABBRO

Greenstone derived from mafic igneous rocks is found throughout the Fennell succession and makes up more than half of the formation. It comprises pillowed and massive flows as well as sills, dykes and small plugs. Both extrusive and intrusive varieties have similar, relatively uniform basaltic compositions (Appendix 2); their chemistry resembles that of ocean-floor tholeiites.

The upper structural division of the Fennell Formation consists mainly of aphanitic to very fine-grained greenstone, much of it pillowed, which is predominantly extrusive in origin. Similar metabasalt, also pillowed in places, is present in the lower structural division, but is subordinate to coarser grained diabasic and gabbroic rocks. Medium to coarse-grained gabbro occurs as sills and semiconcordant plugs up to several hundred metres in thickness. Fine to medium-grained diabasic rocks typically occur as more or less concordant sill-like bodies, up to several tens of metres thick, intercalated with cherty metasediments. Locally the diabase crosscuts adjacent metasediments indicating that here, at least, it is of intrusive origin. Contact relationships are often obscured by tectonism and drift cover so that in many places it is not clear whether specific horizions of fine-grained greenstone are intrusive or extrusive.

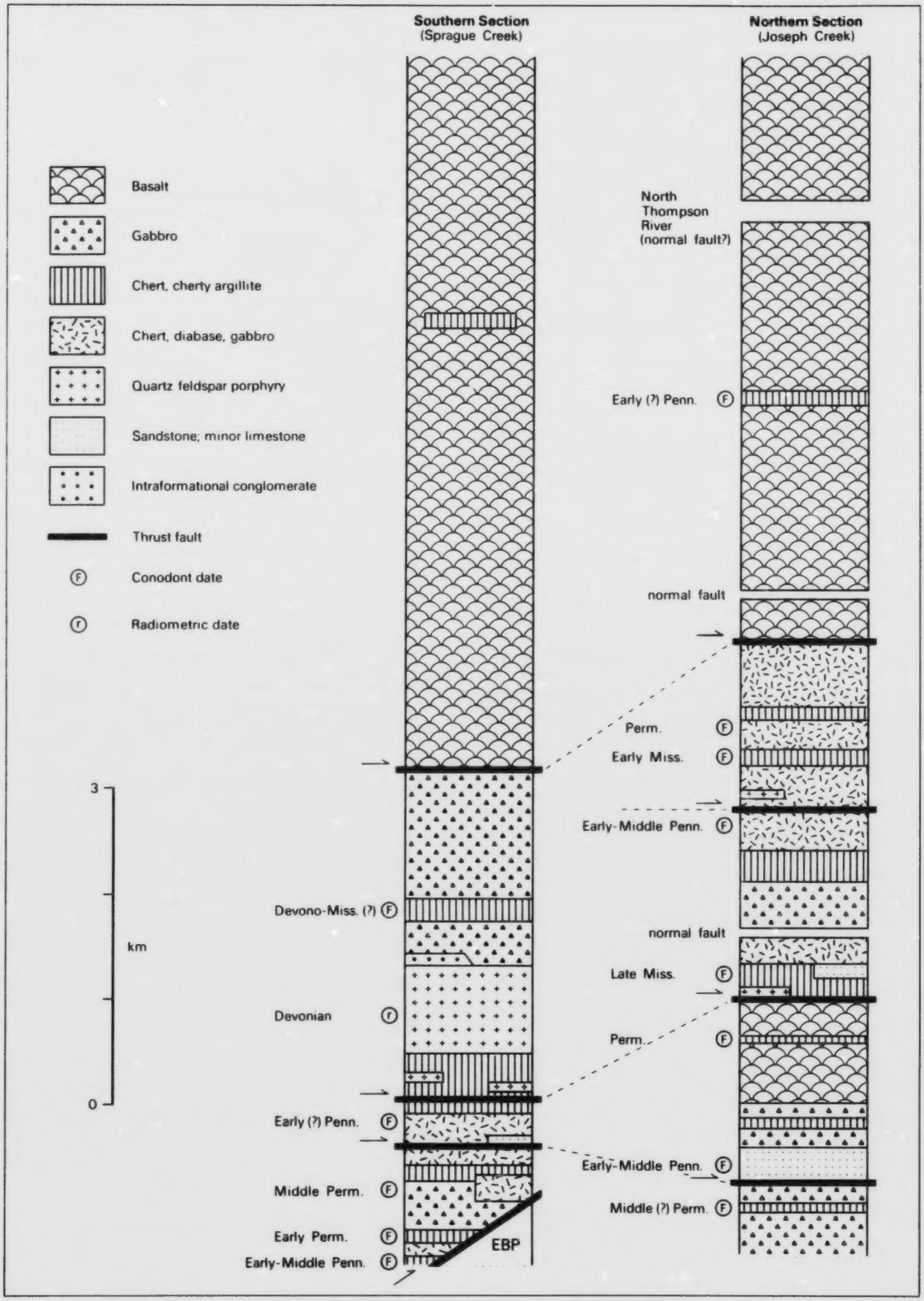

Figure 10. Schematic structural/stratigraphic sections through the Fennell Formation.

Fennell Formation basalts are aphanitic to very fine-grained rocks, medium to dark grey or green in colour. They do not generally display a tectonic foliation, although relatively chloritic, variably foliated varieties occur locally. Constituent minerals are not usually visible in hand specimen, although small phenocrysts of pyroxene or plagioclase are conspicuous in places. Light grey-weathering varioles, several millimetres to more than 1 centimetre across, are common in pillowed basalts where they outline the pillow structures (Plate 13). Other than pillows, primary features are not recognized and Fennell basalt is typically massive and structureless over intervals of many hundreds of metres.

Pillowed masses (Plate 14) occur over intervals up to several tens of metres thick which pass both laterally and vertically into unpillowed basalt. Individual pillows range from a few tens of centimetres to more than a metre across. In many exposures the pillows are tightly packed and molded around one another; pillow breccias are also present, containing isolated, more or less complete pillows together with broken pillow pieces and chert and greenstone fragments, set in a fine-grained tuffaceous matrix. Varioles typically occupy a zone several centimentres wide near the outer margin of the pillows; commonly they are most abundant in the outer part of this zone, where they may coalesce into a more or less continuous mass. Small (≤1 mm) vesicles are sparsely scattered through lower division basalt at one locality near the McCarthy Mountain microwave station, but neither vesicles nor amygdules are generally evident within Fennell Formation basalts. The general absence of vesicles is probably indicative of a deep water origin (Moore, 1965).

Fragmental greenstone of possible pyroclastic origin is rare within the Fennell succession. The best exposures seen by the writers are within the upper divison on the west side of Queen Bess Ridge, about 1 kilometre north of Dunn Creek. Here the rock consists of angular to subangular clasts of basalt, and rarely of chert, within a fine-grained, light to medium green tuffaceous greenstone matrix.

In thin section, Fennell metabasalt is seen to consist mainly of relict grains of clinopyroxene and plagioclase variably altered to a metamorphic assemblage dominated by chlorite, actinolite, epidote, leucoxene, sphene and minor carbonate and quartz. Opaque oxides of probable relict igneous origin are typically present in minor amounts and brown hornblende, which occurs locally, also appears to be relict. Olivine or its pseudomorphs were not recognized. Relict grains of clinopyroxene and plagioclase occur mainly as microphenocrysts, either singly or in glomeroporphyritic clusters. Clinopyroxene microphenocrysts may be highly altered or relatively fresh and altered only along their margins or along fractures. Plagioclase grains are albitized and are usually cloudly due to saussuritic alteration; locally they display rims of relatively fresh albite. Original groundmass textures and mineralogy are generally obscured by metamorphism, although altered grains of clinopyroxene and plagioclase with an intergranular texture may be evident.

Fennell Formation diabase and gabbro are compositionally similar to the metabasalts, both in relict igneous mineralogy and in their metamorphic assemblages. Apatite is locally an important constituent of the gabbroic rocks and relict hornblende is more common in gabbro than in basalt. Diabasic rocks are locally porphyritic and relict intergranular or subophitic textures may be preserved in the groundmass. Gabbroic rocks typically consist of an equigranular intergrowth of saussuritic plagioclase and variably altered mafic grains (clinopyroxene and/or hornblende).

Greenstone of the Fennell Formation is in part Permian in age, as pillowed basalt within the upper division and the second and third fault slices of the lower division is locally intercalated with Permian chert (Appendix 1, Samples MC11, PS81-135 and V2). Intrusive phases of the greenstone cut bedded chert units of Permian age within all lower divison fault slices and are therefore Permian or younger in age. Early (?) Pennsylvanian chert (Sample PS81-1) within the upper Fennell division north of Hallamore Lake suggests that the enclosing basalts in this area may be Pennsylvanian, although contact relationships between the chert and basalt were not observed. Older greenstone units have not been identified in the Fennell Formation, but as most of the greenstone is undated the possibility remains that some is of pre-Pennsylvanian-Permian age.

Chemical analyses for major and selected trace elements have been completed on 50 samples of Fennell Formation greenstone by the Ministry of Energy, Mines and Petroleum Resources analytical laboratory in Victoria. The results are presented in Appendix 2 and the sample locations are indicated in Figure 18. The analysed suite includes 22 metabasalts from the upper Fennell division, 13 metabasalts from the lower division (possibly including some fine-grained diabase sills) and 15 samples of diabasic and gabbroic intrusive rocks from the lower division. Samples selected for analysis were neither veined nor foliated, but are all at lower greenschist metamorphic grade.

The SiO_2 content of the samples indicates a basaltic composition, predominantly tholeiitic according to the major element classification of Irvine and Barager (1971). They are subalkaline according to their hypersthene-normative mineralogy (Appendix 2) and their alkalis versus silica composition (Figure 11a). They plot mainly in the tholeiitic field on an AFM diagram (Figure 11b) although almost half of the upper division basalts fall within the calc-alkaline field. On an Al_2O_3 versus normative plagioclase diagram (Figure 11c), which Irvine and Barager suggest as the best discriminator between tholeiitic and calc-alkaline rocks of basaltic composition, the greenstones are predominantly tholeiitic.

The major element chemistry of the Fennell suite must be treated with caution due to possible element mobility during lower greenschist facies regional metamorphism. Discriminant diagrams based on relatively immobile trace elements provide a more reliable indication of the magmatic affinities (Winchester and Floyd, 1977) and paleotectonic settings (Pearce and Cann, 1973) of altered or metamorphosed volcanic suites. These discriminants (Figures 12 and 13) suggest that the Fennell Formation basalts are ocean-floor tholeiites.

The Y/Nb ratios of the Fennell basalts have minimum values ranging from 2 to 7 (Appendix 2), indicating that they are subalkaline according to the scheme of Pearce and Cann (1973). They also plot in the subalkaline basalt field of Winchester and Floyd's (1977) Zr/TiO_2 versus Nb/Y diagram (not shown since all niobium values fall below the 6 parts per million detection limit, allowing only maximum values for

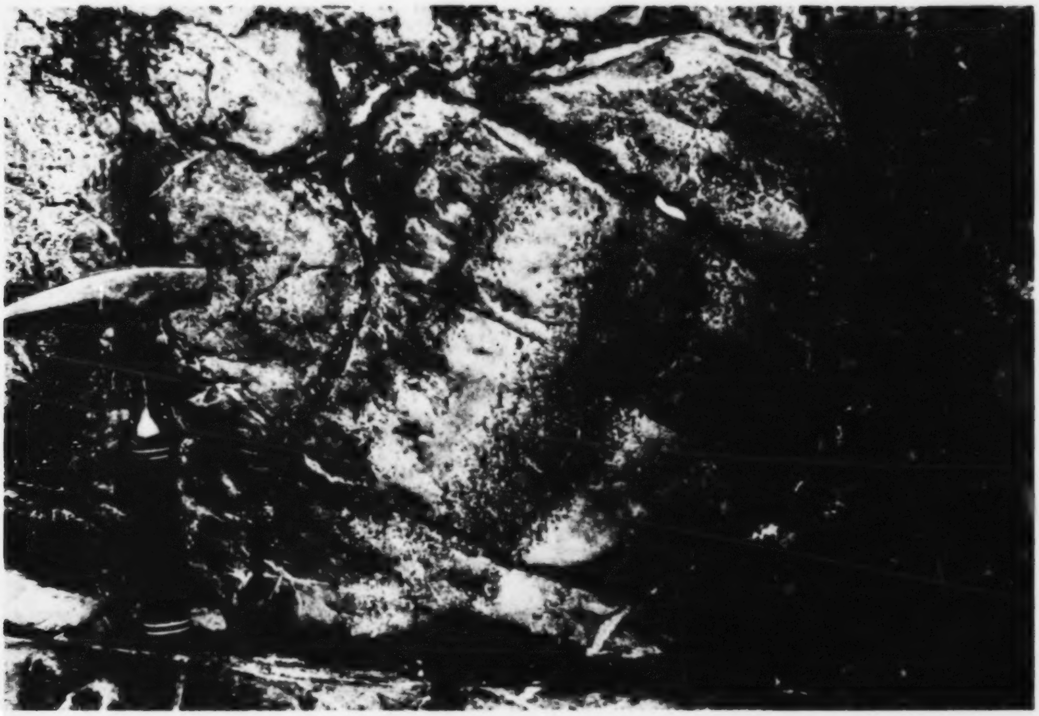

Plate 13. Close-up of variolitic pillow in upper Fennell Formation basalt, Joseph Creek.

Plate 14. Upright pillowed basalt of upper Fennell Formation, Highway 5 north of Little Fort; layering is relatively flat lying at this locality.

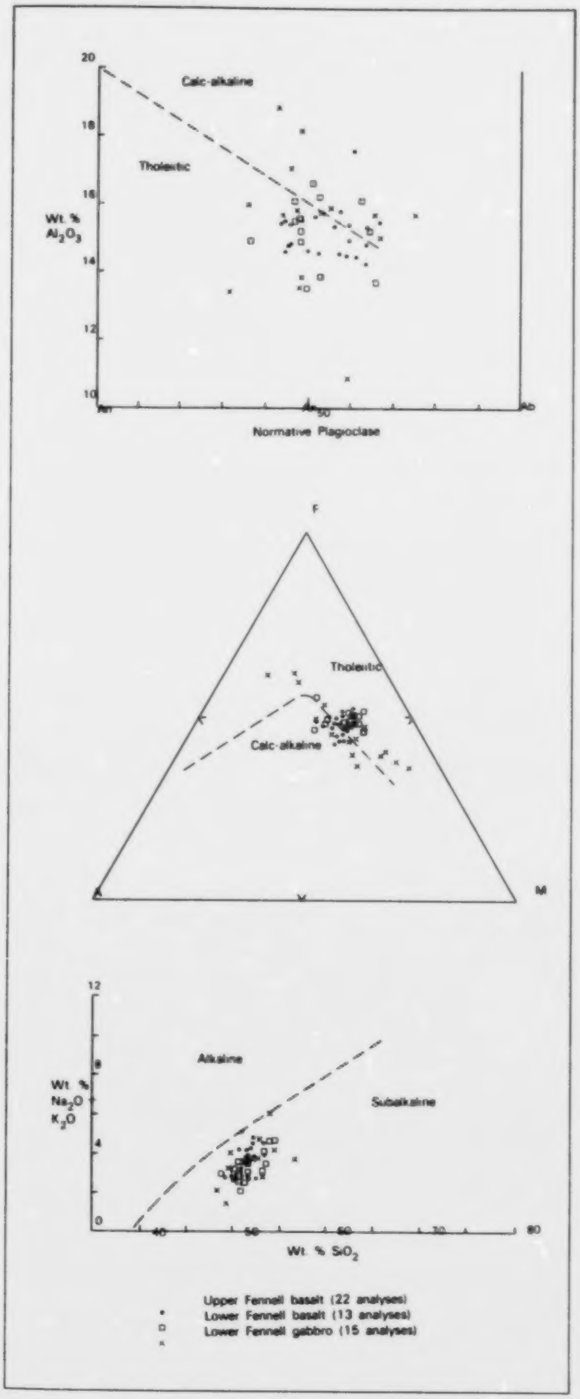

Figure 11. Plots of alkalis versus silca, AFM, and normative plagioclase versus Al_2O_3 for basalt and gabbro of the Fennell Formation.

the Nb/Y ratios to be determined), and are predominantly subalkaline according to the Ti/V <50 criteria proposed by Shervais (1982) (Figure 13c).

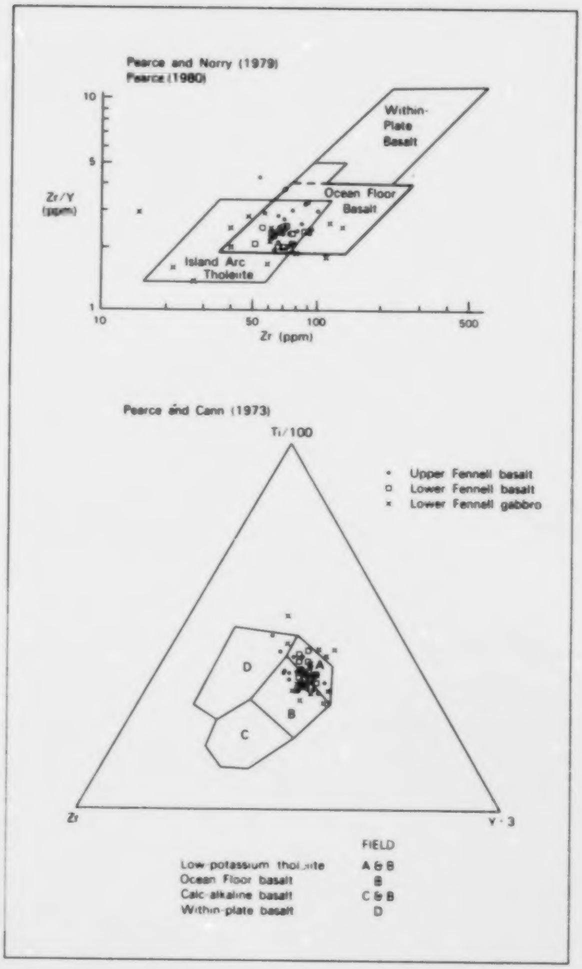

Figure 12. Ti-Zr-Y and Zr/Y versus Zr discriminant diagrams for basalt and gabbro of the Fennell Formation.

The Ti-Zr-Y (Pearce and Cann, 1973) and Zr/Y versus Zr (Pearce and Norry, 1979; Pearce, 1980) diagrams in Figure 12 discriminate within-plate basalts from those extruded in plate margin settings. The Fennell basalts plot outside the within-plate fields and predominantly in the fields shared by island-arc tholeiites and ocean-floor basalts (note that the discriminant diagrams shown in Figures 12 and 13 do not apply to intrusive rocks, and although the lower Fennell gabbros are plotted, they show a wide scatter and are not considered in the discussion).

The titanium versus zirconium (Pearce and Cann, 1973), vanadium versus zirconium (Hawkins, 1980) and vanadium versus titanium (Shervais, 1982) plots shown in Figure 13 discriminate between ocean-floor and island-arc basalts; the last diagram also distinguishes alkalic and ocean-island basalts. The Fennell samples fall mainly in the ocean-floor basalt fields on all of these diagrams, but show some overlap with island-arc tholeiites on the vanadium versus zirconium plot, and with alkalic and ocean-island basalts on the vanadium versus titanium diagram.

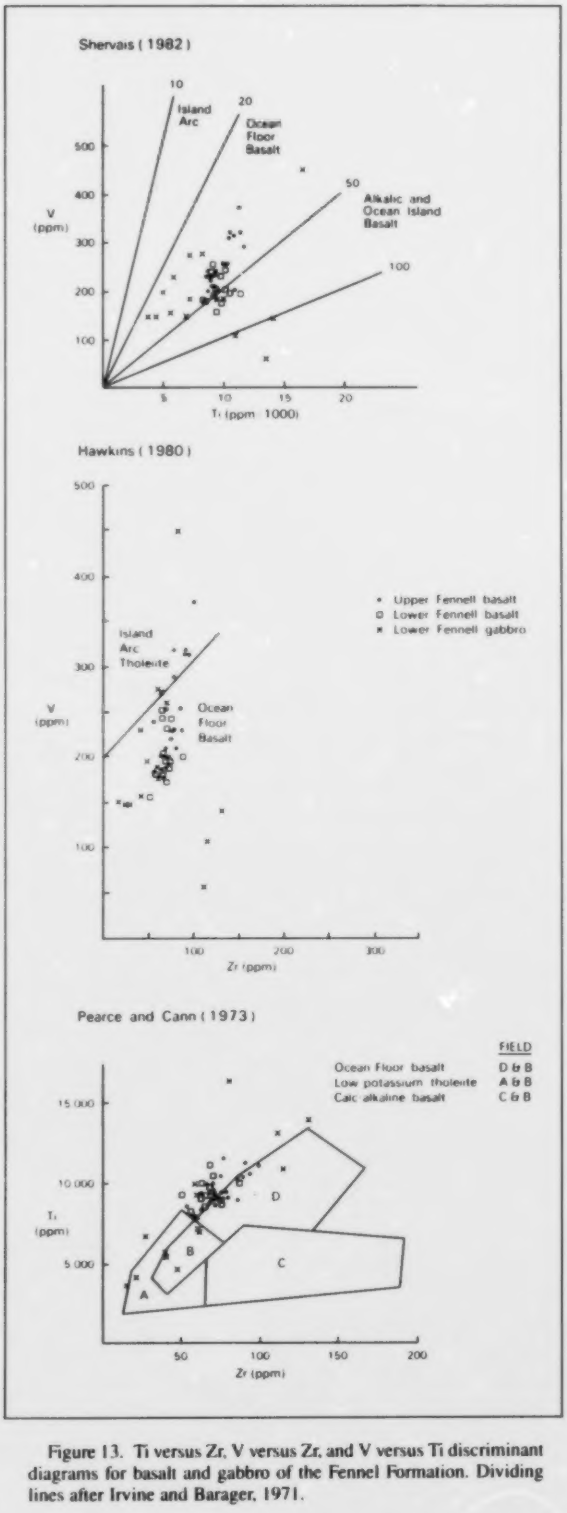

Figure 13. Ti versus Zr, V versus Zr, and V versus Ti discriminant diagrams for basalt and gabbro of the Fennel Formation. Dividing lines after Irvine and Barager, 1971.

The chemistry of the Fennell Formation basalts therefore suggests they are ocean-floor tholeiites, extruded either in a spreading ridge environment, or a marginal or back-arc basin. Similar results were obtained on Fennell basalts analysed by Hall-Beyer (1976) and Aggarwal *et al.* (1984). Aggarwal *et al.*, who studied the rocks at the Chu Chua massive sulphide deposit, also analysed relict clinopyroxene and amphibole phenocrysts and found that they were compositionally similar to phenocrysts found in alkalic and transitional basalts. On this basis they suggested that the Fennell basalts were alkalic to transitional in nature and that the trace element discriminant diagrams, which indicated a tholeiitic composition, did not classify them properly. They further suggested that the basalts formed in a tectonic environment similar to that of present-day oceanic islands or seamounts. This is considered unlikely for most of the Fennell basalts although alkalic basalts might be expected to occur locally within the marginal basin setting that is preferred as the site of origin for the Fennell succession.

BEDDED CHERT

Bedded chert is found throughout the Fennell succession and is the dominant and most characteristic sedimentary rock. It is most prevalent within the lower division where it is found within all fault slices and is intercalated with or intruded by all other rock types common to the division. Chert horizons within the lower Fennell have yielded conodonts ranging in age from Early Mississippian to Middle Permian; older ages are inferred for chert intercalated with Devonian quartz feldspar porphyry. Bedded chert is much less common in the upper structural division, but is present as discontinuous bodies scattered sparsely throughout the upper Fennell basalt. Conodonts extracted from two separate chert lenses within the upper division are Early (?) Pennsylvanian and Middle Permian respectively.

Chert characteristically occurs as well-bedded sequences comprising layers of chert to cherty argillite separated by thinner partings or interbeds of slaty argillite, slate or phyllite (Plate 15). The chert beds are typically 5 to 15 centimetres thick and unfoliated, but may display a crude fracture cleavage, grading to an incipient slaty cleavage in more argillaceous varieties. The interbeds usually display a weakly to strongly developed slaty cleavage. These slaty interbeds range from thin partings less than a millimetre in thickness to beds several centimetres thick, but are usually notably thinner than the associated chert layers. Rarely however, the reverse is true and slate is the dominant rock type while chert is virtually absent or occurs as relatively thin interbeds or lenses. Contacts between the chert and slate beds are usually sharp, but may be gradational over intervals of 1 centimetre or less. Fine laminations were occasionally observed parallel to bedding within both cherty and slaty layers; graded bedding was observed occasionally in thin sections of the slaty interbeds.

Fennell Formation cherts are most commonly pale shades of grey to green in colour, occasionally with a faint and irregular pinkish tint. Medium to dark grey chert is not uncommon and dark green or red varieties are present locally. The slaty interbeds are typically slightly darker shades of the same colours as the associated cherty layers.

In thin section the chert beds are seen to consist mainly of very fine-grained microcrystalline quartz accompanied by varying proportions of sericite (±chlorite), recrystallized

Plate 15. Bedded chert of lower Fennell Formation, Sprague Creek.

quartz ovoids and detrital grains (mainly quartz). Fine-grained opaque grains and patches of late carbonate (calcite and/or siderite) are additional components that may or may not be present. Both conodonts and radiolaria have been extracted from the cherts by M.J. Orchard of the Geological Survey of Canada; only the conodonts have been useful for dating purposes (Appendix 1). The microcrystalline quartz comprises randomly oriented grains less than 0.01 millimetre in size with indistinct and apparently irregularly shaped grain boundaries; patches of slightly coarser equant grains, characterized by straight contacts and triple junctions, are present locally. Small oriented flakes of sericite are invariably scattered throughout the microcrystalline quartz and comprise anywhere from 5 to 30 per cent of the rock. Also present are ovoid patches, 0.05 to 0.2 millimetre across, made up of distinct grains of clear recrystallized quartz which are coarser than the surrounding microcrystalline quartz and are free of detrital grains and sericite. These ovoids comprise as much as 30 per cent of some specimens. They are most abundant in specimens rich in microcrystalline quartz and are rare to absent in specimens with a high detrital component; they may be derived from recrystallized radiolarian tests. Detrital grains were observed in most specimens from the cherty layers, and comprise anywhere from less than 1 per cent to as much as 30 per cent of the specimen. These clastic grains are mainly quartz, but plagioclase, tourmaline, zircon and detrital muscovite were also noted. They are usually in the range of 0.02 to 0.05 millimetre in diameter and are typically angular to subrounded and have low sphericity.

Most samples from the slaty interbeds that have been examined in thin section are clearly derived from clastic rocks (metasiltstones), although in some cases they are now comprised of a fine-grained foliated mass of quartz, sericite and chlorite in which there are no traces of the original texture. The clastic varieties consist of discrete detrital grains within a fine-grained, typically well-foliated matrix of quartz, sericite and chlorite. The detrital grains are similar in composition, size and shape to those within the cherty layers; these rocks are therefore essentially gradational into the relatively clastic-rich varieties of the cherty layers. They are also very similar to the slates and phyllites intercalated with the sandstone horizons within the lower Fennell Formation.

QUARTZ FELDSPAR PORPHYRY

Concordant bodies of quartz feldspar porphyry, derived from rhyolitic extrusive and/or hypabyssal intrusive rocks, occur at a number of places within the lower division of the Fennell Formation but are apparently restricted to the uppermost (third and fourth) fault slices. These rocks are intercalated with cherty metasediments, are intruded by gabbroic rocks, and locally occur as clasts within Fennell Formation intraformational conglomerate; they are therefore clearly an integral part of the Fennell succession. Zircons extracted from the largest porphyry body have yielded a Devonian radiometric age.

The Fennell quartz feldspar porphyries are rhyolites (Appendix 2) comprising quartz and feldspar phenocrysts within a siliceous aphanitic matrix. The matrix is generally light to medium grey in colour, but may be dark grey or light to medium shades of green to grey-green. It commonly weathers to a light chalky grey to green colour. Phenocrysts of quartz and feldspar are ubiquitous and comprise from 1 to 30 per cent of the rock. They are typically 1 to 5 millimetres in size and rarely as large as 1 centimetre. The quartz is generally present as clear glassy grains with roundish outlines, while the feldspar occurs as euhedral to anhedral crystals which weather to a chalky white colour. The porphyry units are typically massive and homogeneous in appearance, although brecciated textures are present in places. A weakly developed tectonic foliation, parallel to the slaty cleavage in adjacent metasediments, is locally apparent.

In thin section the matrix is seen to consist of a very fine-grained mass of quartz and feldspar containing scattered small flakes of metamorphic sericite (±chlorite) or stilpnomelane. The phyllosilicates may be randomly oriented or display a weakly defined preferred orientation; locally the sericite is concentrated in thin laminae which define a metamorphic foliation. Small patches of secondary calcite are present locally, and relict grains of zircon, opaque oxides and apatite are generally present in minor quantities. Apparent relict perlitic fractures were noted in one specimen, suggesting that the matrix may have originally been glassy. The phenocryst assemblage comprises either quartz-plagioclase or quartz-sanidine-plagioclase. Quartz and sanidine crystals are generally fresh and unaltered, often with partially resorbed margins. Plagioclase phenocrysts are commonly altered to a fine-grained assemblage of sericite, chlorite, calcite and quartz. Where relatively unaltered, the plagioclase is albite and may be perthitic.

Quartz feldspar porphyry outcrops most extensively near the headwaters of Sprague Creek, in the southern part of the Fennell belt (Figure 4), where it occurs within the third lower Fennell fault slice. A concordant porphyry horizon, up to 800 metres thick in this area, probably represents a rhyolite dome or high level intrusion. Similar quartz feldspar porphyry occurs as thin sills and dykes intruding underlying cherty metasediments and also as clasts in overlying conglomerate. This horizon passes southward into a zone of intercalated quartz feldspar porphyry, chert and gabbro which can be traced for 4 kilometres south of the main porphyry exposures, but was not identified farther to the south, in the poorly exposed area directly north of the Barriere River. The main porphyry body appears to pinch out to the north, although small exposures of quartz feldspar porphyry occur along strike as far north as Chu Chua Moutain. A lens of quartz feldspar porphyry which crops out between the Baldy batholith and the Joseph Creek stock, 12 kilometres farther north, appears to occupy a similar structural/stratigraphic position near the base of the third fault slice (Figures 4 and 10).

The only other mappable porphyry unit comprises a 50-metre-thick concordant layer, traced for approximately 3 kilometres on the west limb of the Rennie Creek syncline, southeast of Blackpool. This unit is associated with gabbro, cherty metasediments and siliceous phyllite (some of which may be derived from acidic tuff related to the porphyry) within the fourth lower Fennell fault slice.

Other exposures of quartz feldspar porphyry within the Fennell Formation are not sufficiently extensive to be shown on the geological map. These minor occurrences are restricted to the third and fourth fault slices of the lower division of the formation.

The thick quartz feldspar porphyry body on Sprague Creek is assigned a Devonian age based on uranium-lead dating of three zircon fractions extracted from it (Preto, 1981; R.L. Armstrong, written communication, 1982). The three data points fall close to the $^{206}Pb/^{238}U$ – $^{207}Pb/^{235}U$ concordia curve and yield individual uranium-lead dates ranging from 356 million years (Ma) (Lower Mississippian) to 383 Ma (Middle Devonian). They plot near the same discordia line as three samples of Eagle Bay felsic metavolcanic rocks (Unit EBA) from the east side of Adams Lake; this line has an upper concordia intercept of 387±4 Ma (Middle Devonian) which provides the most likely estimate of the age of both the Eagle Bay and Fennell suites (R.L. Armstrong, written communication, 1982). Other quartz feldspar porphyry bodies within the Fennell Formation are spatially associated with the Devonian unit on Sprague Creek as they are restricted to the upper fault slices within the lower division of the formation. These units are therefore also inferred to be of Devonian age.

SANDSTONE AND ASSOCIATED ROCKS

Sandstone, intercalated with siltstone, slate and phyllite, is the dominant component of Unit lFs, which occurs at the base of the second lower Fennell fault slice and has been traced for most of the length of the study area. Sandstone occurs elsewhere within the lower Fennell division as discontinuous lenses intercalated with cherty metasediments, and too limited in extent to be represented on the geological map. The sandstones of Unit lFs are quartz-rich wackes very similar to those of Unit EBP, and are sometimes interfingered with limestone and feldspathic metatuff which is similar to that within Units EBF and EBP. However, the sandstone is also intercalated with typical Fennell bedded chert and is locally intruded by Fennell gabbro. It was therefore deposited within the Fennell basin and does not comprise structural imbrications of Unit EBP. The Fennell Formation sandstones, together with associated limestone and metatuff, are interpreted to comprise redeposited Eagle Bay sediments which were transported to the Fennell basin by mass-gravity processes.

Unit lFs has been traced continuously from Clearwater to the northern margin of the Baldy batholith; it reappears on the southern margin of the batholith and can be traced an additional 8 kilometres to the south. The unit has a cross-sectional thickness which varies from 100 to 350 metres between the Baldy batholith and the Blackpool fault, 2.5 kilometres south of Clearwater; the effects of internal folding and faulting on this thickness are not known. It is offset 2 kilometres along the Blackpool fault, north of which its thickness increases dramatically, but is almost certainly exaggerated by folding and faulting. It thins southward from the Baldy batholith and is less than 10 metres thick where last seen 8 kilometres south of the batholith contact. It may pinch out or be truncated by the underlying thrust fault southward from this point, although exposures are not sufficient to be certain that it does not continue further. Sandstone exposures directly north of the Barriere River fault, 5 kilometres east of Barriere, are mapped as the same unit, but this is not proven as the detailed structural/stratigraphic divisions within the lower Fennell have not been traced into this area. A sandstone lens outcropping 4.5 kilometres northwest of Foghorn Mountain is also mapped as Unit lFs and is inferred to lie at the base of an imbricate thrust within the second lower Fennell fault slice.

Constraints on the age of Unit lFs are provided by Early-Middle Pennsylvanian conodonts extracted from bedded chert within it directly south of Clearwater (Appendix 1; Sample PS81-121) and by Early (?) Pennsylvanian conodonts extracted from a chert horizon directly overlying the unit, 8 kilometres south of the Baldy batholith (Sample S124).

The sandstones within Unit lFs vary from fine to coarse grained and from light to dark grey in colour. They may be massive, or occur in well-bedded intervals in which they are intercalated with slate or phyllite (Plate 16). Individual sandstone beds range from a few centimetres to as much as 60 centimetres in thickness. The beds are locally graded, and may be turbidite deposits. Intercalated slate or phyllite horizons are typically only a few centimetres thick, but in places may be as thick as the associated sandstone beds. Individual beds may be parallel-sided and continuous over the length of an outcrop or may be conspicuously lenticular over similar distances.

The sandstones and siltstones in many exposures of Unit lFs show every gradation between distinctly bedded sandstone and slate in which some sandstone beds are broken apart and disrupted, and conglomerate in which angular to subrounded sandstone clasts occur within a slaty matrix. In some outcrops the sandstone "clasts" have the form of moderate to well-rounded ellipsoids, several tens of centimetres in diameter, resembling ball and pillow structure (Pettijohn and Potter, 1964). The gradation from bedded sandstone to conglomerate is similar to that observed in bedded chert and chert-pebble conglomerate elsewhere within the lower Fennell succession and is likewise attributed to intrabasinal slumping, perhaps related to local faulting and uplift. Disrupted sandstone bedding in a few exposures directly south of Clearwater outlines folds which appear to predate the penetrative synmetamorphic deformation in the area; these may be slump folds related to this process. Alternatively, these slump folds, and disrupted bedding elsewhere within Unit lFs, may be earlier features related to mass-gravity transport of the sandstone and related rocks to the Fennell basin.

The sandstones of Unit lFs are remarkably similar in composition to those of Unit EBP of the Eagle Bay

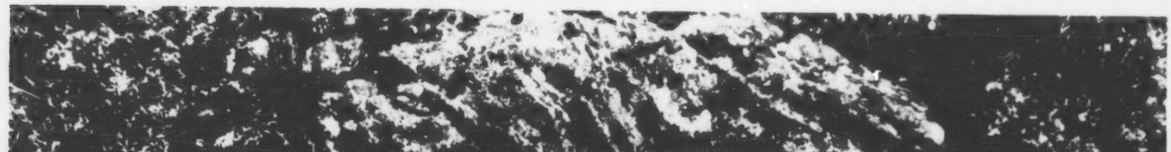

Plate 16. Well-bedded sandstone and slate of the lower Fennell Formation, east of Chu Chua Mountain.

Assemblage; compositions of six representative samples are as follows:

	Range (%)	Mean (%)
Monocrystalline quartz	40-65	58
Polycrystalline quartz	<1-30	12
Plagioclase	<1-10	3
Chert	<1- 3	2
Quartz-sericite rock fragments	0-10	3
Accessories (tourmaline, zircon, detrital muscovite)	<1	<1
Recrystallized matrix	14-40	21

Altered mafic grains (clinopyroxene and/or olivine) were noted as rare detrital grains in two thin sections. The recrystallized matrix component consists mainly of quartz-sericite±chlorite with rare carbonate and opaque oxides. Typical detrital grains are poorly size-sorted; they are of moderate roundness and low to moderate sphericity, although their original shapes are largely obscured by deformation and recrystallization.

Limestone, metatuff and bedded chert are relatively minor components of Unit IFs; they are most common in the area between Clearwater and the Baldy batholith. Limestone occurs mainly as two separate lenses, one directly west of Foghorn Mountain, the other 6 kilometres south of Clearwater (Schiarizza, 1983). Each lens includes intercalations of phyllite and sandstone. The larger southern lens is apparently several tens of metres thick, although this thickness may be exaggerated by internal folding. Both limestone bodies are recrystallized to the extent that their original textures are obscure; samples were examined for microfauna with negative results. Greenish grey metatuff occurs locally as lenses and beds ranging from several centimetres to several metres in thickness. It consists of 1 to 2-millimetre clasts of feldspar and quartz within a fine-grained, more or less foliated chlorite-sericite-quartz matrix. These rocks are very similar to the feldspathic metatuffs which characterize Unit EBF and which also occur intercalated with the slate and sandstone of Unit EBP.

Sandstone is present elsewhere within the lower division of the Fennell Formation as isolated exposures with little apparent continuity. It generally occurs in lenses ranging from a few centimetres to several metres thick, intercalated with bedded chert. These were noted most commonly within an apparently discontinuous horizon of cherty metasediments at the base of the third fault slice in the area between Joseph Creek and the Blackpool fault, just south of Clearwater; lenses of light to medium grey recrystallized limestone, several centimetres thick, are locally intercalated with the sandstone. Late Mississippian conodonts have been extracted from chert within this unit immediately south of the Blackpool fault (Appendix 1; Sample PS81-123).

INTRAFORMATIONAL CONGLOMERATE

Intraformational conglomerate occurs as relatively thin and discontinuous lenses throughout the lower division of the Fennell Formation but is not a volumetrically important component. Conglomerates are present in all fault slices recognized within the lower division; the ages of conglomerate horizions are not well constrained, although at one locality chert-pebble conglomerate passes along strike into bedded chert containing Early (?) Pennsylvanian conodonts (Appendix 1; Sample S124). The clasts within the conglomerates are derived exclusively from Fennell Formation lithologies and in many places are clearly of very local origin. The conglomerates probably reflect local uplift within the Fennell basin, possibly due to block faulting in an extensional environment.

The best exposures of conglomerate occur at the McCarthy Mountain microwave station, 10 kilometres east of Lemieux Lake, where two separate conglomerate lenses are intercalated with bedded chert and fine-grained greenstone within the third lower Fennell fault slice. The lower lens comprises an interval of 70 to 80 metres, which includes relatively minor proportions of greenstone and chert. The conglomerate consists of angular clasts of chert, cherty argillite and greenstone in a moderately foliated, dark grey, siliceous phyllite matrix. The clasts comprise from 40 to 90 per cent of the rock. They range up to 20 centimetres in longest dimension, although most are 6 centimetres or less in length, and are flattened in the plane of the phyllitic cleavage. Fine-grained greenstone occurs within the conglomerate, as more or less concordant lenses with complex and irregular interfingering contacts. Locally the greenstone contains clasts of both greenstone and chert. These relationships suggest that extrusion of the greenstone was contemporaneous with conglomerate deposition.

The upper conglomerate unit is similar, but contains mainly chert and cherty argillite clasts. It is a few tens of metres thick and is separated from the lower horizon by several tens of metres of fine-grained (extrusive ?) greenstone.

A poorly exposed but relatively extensive unit of conglomeratic rocks, apparently up to 100 metres thick, outcrops on both limbs of the Rennie Creek syncline, southeast of Blackpool. The rocks throughout most of this interval comprise angular to subrounded clasts of chert, up to 5 centimetres in size, scattered sparsely throughout a medium to dark grey matrix of siliceous slate. Medium green siltstone is present locally, either as discrete clasts or as thin discontinuous lenses and disrupted beds. Dark grey siliceous slate to cherty argillite without clasts is present locally, as is clast-supported chert-pebble to cobble conglomerate with clasts up to 20 centimetres in size. This unit occurs within the fourth lower Fennell fault slice, where it is overlain by massive metabasalt and is underlain by a poorly exposed interval of gabbro, sandstone, siliceous phyllite and quartz feldspar porphyry; its contacts are not exposed.

A relatively persistent conglomerate unit which occurs above (west of) the large quartz feldspar porphyry body in the southern part of the Fennell belt contains clasts of porphyry, chert and cherty argillite. The clasts are poorly sorted and range from a few millimetres to 15 centimetres across. They are angular and typically tightly packed with a grey, weakly foliated, siliceous argillite matrix. The porphyry clasts, which are presumably derived directly from the underlying porphyry unit, comprise up to 60 per cent of the rock, but are only a minor component in some exposures. Rare lenses of finer grained granule conglomerate, up to 2 metres thick, occur locally within this interval and consist of subangular to subrounded chert clasts tightly packed in a fine-grained siliceous matrix.

Most other conglomerate occurrences within the lower division of the Fennell Formation are isolated exposures which cannot be traced for any distance. Chert and cherty argillite are the dominant, and in many cases the only clast types present; fine-grained greenstone, sandstone and quartz feldspar porphyry are present locally. These horizons generally do not display any internal stratification and clasts are typically angular and poorly sorted. In places chert-pebble to cobble conglomerate passes along strike into bedded chert, through outcrops in which recognizable bedding is broken apart and disrupted. Rare exposures of conglomerate are comprised of moderately well-sorted subrounded clasts and display internal stratification. These clasts may have been transported for moderate distances within the Fennell basin.

SOUTHERN SECTION

A schematic section through the Fennell Formation in the southern part of the belt (Figure 10) has been drawn through the vicinity of upper Sprague Creek and Chinook Mountain. In this area the lower division consists of three recognizable fault slices aggregating 3500 metres of strata, while the upper division comprises approximately 8000 metres of mainly undivided basalt.

The lowest fault slice comprises 350 to 400 metres of diabase and gabbro containing thin screens of bedded chert and siliceous argillite. A unit of bedded chert in the central part of the slice is close to 100 metres thick and has been traced for 6 kilometres to the north. Rocks within this fault slice overlie black phyllite and siltstone of Unit EBP; the contact was not observed but is constrained by outcrops of Fennell Formation and Unit EBP approximately 125 metres apart. Conodonts from a thin chert sliver, within diabasic rocks of the lowest Fennell exposure along the line of section, are of Middle Permian age (Appendix 1, Sample S13).

Six kilometres to the north, near the Enargite lead-zinc showing, an additional 500 metres of strata are present in the lowest fault slice. These additional strata appear gradually, above the contact with Unit EBP, reflecting a southward truncation of basal Fennell units along the contact. A gabbroic sill occupies the upper half of this additional section while the lower part is comprised of intercalated chert, siliceous argillite and fine-grained greenstone. Early-Middle Pennsylvanian conodonts (Sample V90) were extracted from a chert horizon a few tens of metres above the EBP contact, near the Enargite showing, and Early Permian conodonts (Sample V90A) were extracted from cherty metasediments approximately 90 metres higher in the section. These dates confirm that the rocks within the lowest fault slice face west, and provide additional documentation of the truncation of basal Fennell units southward along the EBP contact.

The second fault slice is also 350 to 400 metres thick along the line of section. It consists of gabbroic rocks containing thin screens of bedded chert, overlain by a unit of bedded chert approximately 100 metres thick. The upper chert unit has been traced for almost 7 kilometres, mainly to the north of the line of section. Four kilometres to the north, the basal section of the second fault slice includes sandstone of Unit IFs which has been traced more than than 8 kilometres northwards to the Baldy batholith. Unit IFs is directly underlain by Permian chert (Sample S140) approximately 7 kilometres north of the line of section, and is overlain by Early (?) Pennsylvanian chert (Sample S124) 3 kilometres south of that point. A thrust fault is therefore present either directly above or below the sandstone unit. It is placed at the base of Unit IFs because the sandstone appears to be stratigraphically linked to the overlying Pennsylvanian chert by an intervening gabbro sill which shows intrusive relationships to both underlying sandstone and overlying chert. This is consistent with relationships in the northern part of the study area, where Unit IFs, comprising the basal part of the second thrust slice, includes Early-Middle Pennsylvanian chert (Figure 10).

The third lower Fennell fault slice is 2500 to 3000 metres thick along the line of section. It includes a unit of quartz feldspar porphyry 800 metres thick, which has yielded a Devonian radiometric age and is therefore older than the underlying rocks of the second fault slice. The thick porphyry unit is underlain by 400 metres of medium to dark grey cherty argillite, chert and phyllite which contain thin sills and dykes of quartz feldspar porphyry, possibly part of a feeder system to the overlying unit. The thrust fault separating the second and third fault slices is placed at the base of this unit. The quartz feldspar porphyry is overlain by a discontinuous conglomerate horizon which locally contains porphyry clasts in addition to clasts of chert and cherty argillite. Diorite and gabbro, 1500 metres thick along the line of section, dominate the upper part of the third fault slice. A chert horizon within the lower portion of this intrusive mass (Figure 4) has yielded Devono-Mississippian (?) conodonts (Sample D68), confirming the relatively early age of parts of this fault slice.

The rocks of the third fault slice pass southward from the line of section into a zone of complexly intercalated quartz feldspar porphyry, gabbro and bedded chert. To the north, the basal interval of cherty metasediments and a large part of the overlying porphyry unit are apparently truncated against the underlying thrust fault. Isolated exposures of quartz feldspar porphyry continue almost as far north as the Baldy batholith, however, and the thrust at the base of the third slice is projected northward so as to lie east of all known porphyry exposures; its inferred position is very approximate for much of its length between the line of section and the batholith. The thick intrusive mass comprising the upper part of the third fault slice along the line of section passes northward into a poorly exposed interval of largely gabbroic sills and cherty metasediments. Still farther north, near Chu Chua Mountain, the upper part of the third slice includes pillowed basalt intercalated with a number of horizons of bedded chert, one of which has yielded Permian conodonts (Sample V2). Top determinations from a pillowed basalt confirm that these rocks face west.

The upper division of the Fennell Formation along the line of section comprises approximately 8000 metres of mainly undivided basalt. Thin intercalations of bedded chert, sparsely scattered through the interval, indicate that the rocks dip steeply. Top determinations on pillowed basalt, at six widely scattered localities between Leonie Creek and Dunn Creek, indicate that the rocks face west, as does the footwall alteration zone of the CC massive sulphide deposit east of Chu Chua Mountain (McMillan, 1980). Middle Permian conodonts were extracted from a thin chert horizon intercalated with pillowed basalt in the lower portion of the division approximately 5 kilometres south of the line of section (Sample MC11). By analogy with the lower structural division, however, the upper division may comprise a number of imbricate slices and may span a considerable time interval.

NORTHERN SECTION

A section through the Fennell Formation in the northern part of the study area is drawn between Foghorn Mountain and Lemieux Lake. The lower Fennell division in this area comprises three fault slices, totalling approximately 4700 metres of strata and corresponding to the second and third fault slices in the southern part of the area, together with an overlying fourth fault slice (Figure 10). Rocks of the lowest fault slice are exposed only north of the line of section where they gradually appear from beneath the adjacent overthrust rocks of the Eagle Bay Assemblage (Figure 4). These rocks are projected into the section (Figure 10). The upper division of the Fennell Formation along the line of section comprises approximately 3700 metres of strata on the east side of the North Thompson River valley, and an additional 1500 metres of presumably overlying rocks on the west side of the river.

The first lower Fennell fault slice comprises mainly diabase and gabbro with intercalations of bedded chert; greenstone of probable extrusive origin occurs locally in the upper part of the slice. A chert horizon in the upper part of this slice, exposed 9 kilometres north of the line of section, has yielded Middle (?) Permian conodonts (Sample PS81-50). The base of this slice reaches the surface only in the small fault-bounded block directly south of Clearwater, where the underlying rocks of Unit EBP are exposed (Figure 4). The slice is approximately 600 metres thick in this area, although this thickness may be exaggerated by internal folding. South of the Blackpool fault, the rocks of the lower fault slice are structurally overlain, across an east-dipping thrust fault, by rocks of Units EBA and EBF. They are progressively truncated southward below this fault until the entire lower slice has been overlapped approximately 2 kilometres north of Foghorn Mountain, and adjacent Eagle Bay rocks are juxtaposed directly against clastic metasediments in the lower part of the second fault slice.

The second fault slice comprises approximately 1700 metres of strata along the line of section. The sandstone-dominated Unit 1Fs which occurs at the base of the slice is approximately 350 metres thick in this area, and probably correlates with the sandstone horizon at the base of the second fault slice south of the Baldy batholith. This unit has been traced as far north as Clearwater where Early-Middle Pennsylvanian conodonts (Sample PS81-121) have been extracted from bedded chert included within it. This requires that it must be in fault contact with underlying gabbro and chert of the first fault slice which are, at least in part, of Permian age. Gabbro and chert which lie above the sandstone unit are overlain by several hundred metres of pillowed basalt. A 40-metre interval of bedded chert occurs above this basalt unit and contains Permian conodonts (Sample PS81-135). The chert is overlain by another thick interval of pillowed basalt which comprises the top of the second fault slice; the unit may, however, include one or more thrust repetitions. Top determinations confirming the westerly facing direction of the second fault slice are provided by graded bedding in the sandstone horizon at the base of the slice and by pillows in the basalt units at the top.

The third fault slice is approximately 1500 metres thick along the line of section. Its lower portion comprises a 200-metre interval of bedded chert which also includes minor amounts of sandstone containing thin pods of limestone (Figure 10). These rocks lie directly above the pillowed basalts at the top of the second fault slice. This chert-dominated interval appears to be part of a discontinuous (?) unit which outcrops intermittently as far north as the Blackpool fault and which contains Late Mississippian conodonts at its northern extremity (Sample PS81-123). This chert unit also outcrops south of the Joseph Creek stock and extends 7 kilometres farther south before being truncated by the Baldy batholith. Quartz feldspar porphyry underlying the chert south of the Joseph Creek stock is included within the third fault slice and suggests that it is correlative with the third slice recognized in the southern part of the area (Figure 10). The chert horizon near the base of the third slice is overlain by 250 metres of chert and diabase which, along the line of section, is bounded to the west by a late fault. This fault probably does not cause significant displacement and overlying rocks to the west, included within the third fault slice, comprise a thick gabbroic sill, a 300-metre interval of medium to dark grey bedded chert, and an overlying 350-metre interval of intercalated chert and diabase which comprises the uppermost unit of the third fault slice. Early-Middle Pennsylvanian conodonts (Sample PS81-124) occur near the top of the chert/diabase unit.

Overlying rocks, which are inferred to be at the base of the fourth fault slice, comprise a 400-metre interval of chert and diabase which is similar to the underlying rocks of the upper part of the third fault slice, except that it contains rare exposures of quartz feldspar porphyry. An overlying unit of bedded chert, 150 metres thick, has yielded Early Mississippian conodonts from near its base (Sample PS81-81) which requires that a fault be placed between it and the Pennsylvanian rocks assigned to the upper part of the third slice (Figure 10). The Mississippian chert horizon is overlain by a gabbroic sill, 250 metres thick, which passes southward into a zone of gabbro, diabase and chert; Permian conodonts (Sample PS81-244) have been extracted from the central part of this interval 2.5 kilometres south of the line of section. Overlying rocks comprise 130 metres of bedded chert followed by approximately 600 metres of intercalated diabase, chert and gabbro which lie directly below the basalts of the upper division of the formation.

The fourth fault slice is also recognized north of the line of section, on the north side of the Axel Creek fault, where it is folded by the Rennie Creek syncline. It comprises a lower interval of gabbro, quartz feldspar porphyry, sandstone and chert overlain by a discontinuous conglomerate horizon and an upper unit of metabasalt. Conodonts from bedded chert just below the conglomerate horizon are Late Mississippian in age (Sample PS81-66). The fourth fault slice is not recognized several kilometres south of the line of section where an abrupt thinning of the upper part of the lower Fennell division suggests that it may be truncated along the contact with the structurally overlying upper division.

The upper Fennell division lying east of the North Thompson River along the line of section comprises approximately 1700 metres of strata. These rocks are mainly fine-grained metabasalt which is locally pillowed, but also include a relatively thick and persistent horizon of steeply west-dipping bedded chert, traced over a strike length of 3 kilometres in the vicinity of Hallamore Lake. This horizon has yielded Early (?) Pennsylvanian conodonts (Sample PS81-1). Pillows at three widely scattered localities demonstrate that the rocks dip steeply and face west.

The valley of the North Thompson River is 1.5 kilometres wide along the line of section and devoid of outcrop. Fennell rocks exposed on the west side of the valley comprise approximately 1500 metres of pillowed and massive metabasalts which are presumably higher in the section than those east of the river. Pillows at a number of localities suggest that the rocks west of the river dip (and face) much more gently to the west. This may be the result of west-side-down listric normal faulting within the river valley (*see* Chapter 3).

FENNELL FORMATION CORRELATION AND PALEOGEOGRAPHY

The Fennell Formation correlates with the Antler Formation which outcrops 150 kilometres to the north in the Cariboo River area (Sutherland Brown, 1957, 1963; Struik and Orchard, 1985). Over much of the intervening distance it may be represented by a thin amphibolite unit which occurs along the boundary between Quesnel terrane and adjacent rocks of the Snowshoe Formation (Campbell, 1978; Struik, 1986). The Fennell and Antler Formations are part of the Slide Mountain terrane, which is recognized over most of the length of the Canadian Cordillera. Slide Mountain terrane is broadly equivalent to Monger's (1977) "eastern assemblage" of upper Paleozoic volcanic rocks and comprises the most easterly occurrences of oceanic rocks in the Canadian Cordillera. In southern British Columbia it includes the Kaslo Formation of the Kootenay Arc (Read and Wheeler, 1976) and possibly the Tsalkom Formation of the Vernon map area (Jones, 1959; Okulitch, 1979).

Rocks of the Fennell Formation accumulated in a deep oceanic basin an unknown distance west of partially coeval rocks of the Eagle Bay Assemblage. The oldest dated rocks within the formation are Devonian quartz-feldspar-porphyry rhyolites which are intercalated with bedded chert in the lower division. The basement to these rocks is not exposed. The felsic volcanic rocks are similar to Devonian felsites of the Eagle Bay Assemblage and may represent a more westerly expression of the same igneous event. Deposition of bedded chert continued to Middle Permian time, but locally the basin received deposits of sandstone and associated intermediate tuff and limestone, presumably by mass-gravity flows. These rocks are similar to Devono-Mississippian rocks of the Eagle Bay Assemblage (Units EBP and EBF) and may have been derived from them. This relationship, combined with the link provided by the Devonian felsic volcanic rocks, suggests that the Fennell basin was not far removed from the adjacent Eagle Bay terrane.

Basalt, diabase and gabbro, with the chemical characteristics of ocean-floor tholeiites, are widely distributed in the Fennell Formation. Basalt is intercalated with Permian chert in the second and third fault slices of the lower division and with Permian and Pennsylvanian chert in the upper division. Permian chert is intruded by diabase or gabbro throughout the lower division. These mafic igneous rocks are therefore at least in part Pennsylvanian-Permian (and younger ?) but their lower age limit is unknown.

The distribution of Permian basalt indicates that mafic volcanism was, at least in part, synchronous over most of the basin represented by the imbricated Fennell succession. Fennell ocean-floor volcanism was not, therefore, concentrated in a well-defined spreading centre, but included much off-ridge volcanism and intrusion such as characterizes some present-day marginal basins (Lawver and Hawkins, 1978; Klein *et al.*, 1978). Intraformational conglomerates within the lower Fennell division may have been generated in locally uplifted areas within this active basin. The basalts of the upper division, which include only minor amounts of bedded chert, may represent a more persistent volcanic centre or ridge located farther to the west within the basin. The western margin of the Fennell basin may have been an island arc represented by the Harper Ranch Group of the Quesnel terrane (Monger, 1977; Price *et al.*, 1985, page 3.38).

MESOZOIC ROCKS OF THE QUESNEL TERRANE (TRl and TRJv)

Dark grey limestone (TRl), which is exposed in several road cuts along Lemieux Creek valley north of Eakin Creek, and green augite porphyry breccia and volcanic sandstone (TRJv) which occur near the confluence of Fadear and Louis creeks, are Mesozoic Nicola Group rocks which are widely represented in the Intermontane Belt west of the map area (Campbell and Tipper, 1971; Okulitch, 1979). The limestone, which is of Late Triassic age (Campbell and Tipper, 1971; Okulitch and Cameron, 1976), is juxtaposed against the Fennell Formation across one of a series of closely spaced faults comprising the Louis Creek fault zone where it occupies Lemieux Creek valley between Little Fort and Lemieux Lake (Okulitch, 1979). The volcaniclastic rocks of Unit TRJv outcropping near Fadear Creek occupy a small area surrounded by sparse exposures of black phyllite and siltstone of Unit EBP. The contacts are not exposed but are inferred to be splays from the Louis Creek fault which controls the valley of Louis Creek a short distance to the west.

KAMLOOPS GROUP: CHU CHUA (eTc) AND SKULL HILL (eTs) FORMATIONS

Sedimentary rocks of the Chu Chua Formation (eTc) and overlying andesitic volcanics of the Skull Hill Formation (eTs) unconformably overlie the Fennell Formation at several localities in and adjacent to the North Thompson River valley (Figure 4). These rocks are Eocene in age (Uglow, 1922; Campbell and Tipper, 1971) and are included in the Kamloops Group which comprises Eocene sedimentary and volcanic rocks that outcrop over a broad area in south-central British Columbia. A large outlier of basaltic volcanics, which lies unconformably above Unit EBP in the vicinity of Alex and Haggard creeks, is also tentatively included within this group, as is conglomerate which was mapped along the west side of upper Adams Lake by Campbell (1964). This latter occurrence was not examined during the present study.

The Chu Chua Formation consists of locally derived granule to cobble conglomerate, sandstone, siltstone and shale. Coal occurs locally and a small amount was produced from the lower part of Newhykulston Creek prior to 1923 (Uglow, 1922; Campbell and Tipper, 1971). The Skull Hill Formation in the vicinity of the North Thompson River consists of brownish grey vesicular and amygdaloidal andesite containing amphibole phenocrysts. The volcanics are quite friable, in large part due to the presence of steeply dipping, closely spaced, northerly trending fractures. The Kamloops Group sediments and volcanics exposed on lower Joseph Creek dip eastward at 35 to 40 degrees. They were apparently rotated during movement along an Eocene or younger normal fault which bounds them to the east (Figure 5, section B-B'). Similarly, Eocene rocks exposed elsewhere along this part of the North Thompson River dip persistently eastward (Uglow, 1922) and may be preserved on the west, down-dropped side of late normal faults.

The rocks assigned to Unit eTs in the vicinity of Alex and Haggard creeks comprise mainly brownish weathering, dark grey vesicular to amygdaloidal basalt containing phenocrysts of olivine, and rarely pyroxene and plagioclase. Dark grey carbonaceous mudstone and shale occur locally beneath the volcanics. The basalt is commonly cut by closely spaced, steeply dipping, northerly trending joints and is therefore inferred to be of Eocene age, rather than younger.

OLIVINE BASALT (mTb and Tb)

Olivine basalt (Unit mTb) which outcrops along the Clearwater River was not examined in any detail during the present study. The distribution portrayed on the geological map is after Campbell (1964) and Campbell and Tipper (1971). These flows are the easternmost representatives of an extensive mass of flat-lying, undeformed, late Miocene to Pliocene plateau lavas which cover much of interior British Columbia to the west and northwest of the map area (Campbell and Tipper, 1971; Souther, 1977). A detached erosional remnant of these flows unconformably overlies the Fennell Formation in the western wall of the North Thompson River valley just south of Clearwater; another rests unconformably on Unit EBQ on the northwest slopes of the Raft River valley 5 kilometres east of Clearwater.

Brownish weathering, dark grey olivine basalt (Tb) rests unconformably on quartzite and grit of Unit EBS at two places between Sinmax and Cicero creeks in the southern part of the map area. These rocks appear undeformed, in contrast to the closely fractured and tilted Eocene (?) volcanics and sediments (eTs) which outcrop 6 kilometres to the north between Alex and Haggard creeks; they are therefore inferred to be younger. They may be more closely related to Unit mTb, or to still younger volcanic rocks which occur north of Clearwater (Campbell and Tipper, 1971).

DEVONIAN ORTHOGNEISS (Dgn)

Granitic orthogneiss of Unit Dgn outcrops mainly on the northern and southeastern margins of the Baldy batholith, where it occupies the northwest end of a belt of Late Devonian orthogneiss that extends for about 70 kilometres to the southeast (Okulitch *et al.*, 1975). Within the study area the orthogneiss occurs as a sheet-like body at the base of the third Eagle Bay fault slice (Figure 6); it underlies (and intrudes) Unit EBQ over most of this area, but locally cuts up-section to lie directly beneath Unit EBA. Locally, and particularly in the vicinity of upper Harper Creek, orthogneiss occurs as sill-like bodies which intrude metasedimentary and metavolcanic rocks of Units EBQ and EBA, but are not sufficiently well defined to be mapped separately; the host rocks in these areas are designated as Units EBQgn and EBAgn.

The dominant lithologies within Unit Dgn are medium grey biotite-hornblende-plagioclase-quartz gneiss and light grey muscovite-biotite-orthoclase-plagioclase-quartz gneiss. Epidote, chlorite and sphene are common additional components of the more mafic gneiss and small grains of zircon and apatite occur as accessories in both types. Generally, both varieties are medium grained and monotonously uniform over fairly large areas. The darker gneiss is generally more pervasively recrystallized and foliated; it comprises quartzofeldspathic lenses alternating with or enclosed by lenses and foliae of biotite and hornblende; a lineation defined by mafic streaks and/or rods of quartzofeldspathic rock is often conspicuous. The lighter coloured gneiss is generally less strongly foliated and may display a relict granitic texture. Contacts between the two phases are usually sharp and it generally appears that the light grey gneiss is intrusive into the more mafic variety. Dark grey amphibolitic xenoliths within the biotite hornblende gneiss may represent a still earlier intrusive phase, while weakly foliated leucocratic muscovite-plagioclase-orthoclase-quartz gneiss, which occurs as thin veins and pods that crosscut all other varieties of the gneiss and also metasediments of Unit EBQ, is the latest phase recognized.

Contacts between Unit Dgn orthogneiss and Unit EBQ metasediments were rarely observed; where seen they are sharp and apparently intrusive in nature. No contact metamorphic effects which could be attributed to intrusion of the orthogneiss were discerned through the mask of Mesozoic regional and contact metamorphism. The gneissic foliation and lineation within the orthogneiss are parallel to the dominant (Mesozoic) synmetamorphic schistosity and mineral lineation within adjacent EBQ metasediments. The schistosity within Unit EBQ, however, locally crosscuts an earlier metamorphic foliation which has no apparent counterpart within the orthogneiss. Unit EBQ may, therefore, have been subjected to pre-Late Devonian deformation and metamorphism, as has been suggested by Okulitch (1979).

Gneissic rocks assigned to Unit Dgnp directly south of the Baldy batholith include sillimanite-staurolite-biotite-hornblende-quartz gneiss and calc-silicate gneiss of sedimentary origin together with quartzofeldspathic biotite hornblende orthogneiss. These highly metamorphosed sediments may be part of Unit EBQ, but are distinctive in their relatively coarse-grained gneissic fabric and the presence of sillimanite.

Orthogneiss assigned to Unit Dgn also occurs within the lowest structural slice in the area, where it intrudes Unit EBA and underlying rocks of Unit EBK along both sides of Adams Lake. These intrusive rocks range from massive, medium-grained granitic rocks through crudely foliated gneisses comprising lenses and augen of quartzofeldspathic rock that are enclosed by schistose seams of chlorite and sericite, to well-foliated sericite chlorite schists containing "eyes" of quartz and feldspar. In thin section they are seen to consist mainly of quartz, plagioclase and microcline (and/or perthitic feldspar) with lesser chlorite, sericite, epidote and sphene. Carbonate may also be present and relict grains of apatite and zircon are usually present in trace amounts. Although contacts between the intrusive rocks and adjacent volcanic components of Unit EBA are often indistinct, the intrusives appear to comprise a number of sill-like bodies within the central and lower parts of Unit EBA and underlying rocks of Unit EBK. Orthogneiss samples collected from within this belt have recently yielded a Late Devonian radiometric age (uranium-lead on zircons; L.C. Struik, personal communication, 1986). The orthogneiss intrudes but is presumed to be genetically related to compositionally similar volcanic and volcaniclastic rocks of Unit EBA.

SERPENTINITE (ub) AND METADIORITE (di)

Serpentinite (ub) forms a belt of prominent northwest-trending ridges extending for 12 kilometres from Blucher Hall to Cicero Creek. The serpentinite is a massive to brecciated, dark grey to black rock with scaly masses of green antigorite and, very rarely, short fibres of asbestos. A specimen examined in thin section contained mainly olivine as rounded, possibly cummulate grains, enveloped in a mass of antigorite and magnetite. The serpentinite occupies a fault zone between Unit EBS to the northeast and Units EBM and EBP to the southwest. Its spatial association with the mafic volcanic rocks of Unit EBM suggests that the two may be related.

Foliated diorite and quartz diorite (di) occur as sills, dykes and small plugs mainly within Unit EBS. Similar, possibly related, rocks occur within Unit EBQ and rarely within Units EBA and EBF. Only a few of the bodies were sufficiently large to be portrayed on the geological map (Figure 4). The metadiorite is medium to coarse grained and occurs in medium to dark shades of grey and green. It consists mainly of saussuritic plagioclase with hornblende and/or its alteration products chlorite, actinolite and epidote. Quartz may be abundant or rare, as may secondary carbonate. Apatite and sphene-leucoxene are common accessories. Individual bodies may be strongly foliated to massive; in some instances they become progressively more foliated toward their margins. Metadiorite seems to be most common within Unit EBS metasediments directly beneath Unit EBM and may comprise part of a feeder system to the overlying EBM volcanics.

CRETACEOUS GRANITIC ROCKS (Kg)

Massive granitic rocks of the east-trending Baldy batholith intrude Fennell and Eagle Bay rocks in the central part of the map area and extend from Baldy Mountain to the west shore of Adams Lake. Smaller granitic bodies cut the Fennell Formation in upper Joseph Creek valley, immediately northwest of the Baldy batholith, and along Newhykulston Creek, 9 kilometres southwest of the batholith. The Raft batholith, also elongate in an east-west direction, outcrops along the northern margin of the map area, from its western boundary to the North Thompson River north of Vavenby. The western half of a granitic stock is exposed along the northeastern margin of the map area, east of Robert Creek, and part of a smaller stock is exposed along the southeast edge of the map area, on the east side of Adams Plateau. Potassium-argon age determinations on biotite from two samples from the Baldy batholith have yielded ages of 96±5 Ma and 80±6 Ma (Wanless *et al.*, 1966). The Raft batholith has yielded two somewhat older biotite ages of 105±9 Ma and 140±9 Ma (Wanless *et al.*, 1967). More recent dating, however, provides ages of about 100 Ma for both the Raft and Baldy batholiths (R.L. Armstrong, personal communication, 1986). These Middle Cretaceous granitic rocks postdate most of the penetrative deformation in the area; their emplacement, however, coincided with some of the latest folding and predated late faults, which locally offset the contacts of both the Raft and Baldy batholiths.

Within the map area, contact phases of the Baldy batholith consist mainly of light grey, coarse-grained biotite quartz monzonite. Pinkish potassium feldspar crystals are generally slightly larger than the associated grains of light grey quartz and white plagioclase and in places occur as phenocrysts up to several centimetres in size. Biotite is the predominant mafic mineral and is only locally accompanied by hornblende. Modal analyses of samples from the Baldy batholith presented by Campbell and Tipper (1971, page 73) fall mainly in the quartz monzonite field.

The contacts of the western part of the Baldy batholith, between North Barriere Lake and Granite Mountain, are sharp, steeply inclined and quite regular in orientation (Plate 17). This also seems to be the case along the batholith's northern margin from Granite Mountain to Adams Lake, although the contact is not well exposed in this area. Xenoliths of country rock within the granite are rare and restricted to the contact zone. Veins and pods of granite and aplite invade the country rock for only a few tens of metres beyond the contact and are not abundant. The batholith truncates a number of major structures within the intruded rocks, including easterly directed thrust faults within the Fennell Formation and between the Fennell and Unit EBP, the axial trace of the Slate Creek anticline, and the east-dipping Birk Creek thrust fault which separates the Fennell Formation and Unit EBP of the first fault slice from Eagle Bay rocks of the third slice. Intrusion of the batholith resulted in the development of later west-plunging folds within both the Eagle Bay Assemblage and Fennell Formation along its northern and northwestern margins.

Contact metamorphism associated with the western and northern parts of the Baldy batholith is recognized within a zone which extends into the country rock for 1 to 1.3 kilometres from the contact. This aureole bulges outward along the northwestern margin of the batholith such that it also encloses the Joseph Creek stock. The contact metamorphic effects are most conspicuous in pelitic to semipelitic rocks found within Units EBP, EBA, IFs and IFc. These rocks contain biotite in the outer margin of the aureole and the assemblage quartz-biotite-cordierite±muscovite±andalusite close to the batholith contact. Fennell Formation greenstones within the zone of cordierite-bearing pelitic rocks have been metamorphosed to dark grey, fine-grained equigranular rocks, typically composed of hornblende, andesine, opaque oxides and apatite. Greenstone associated with biotite-

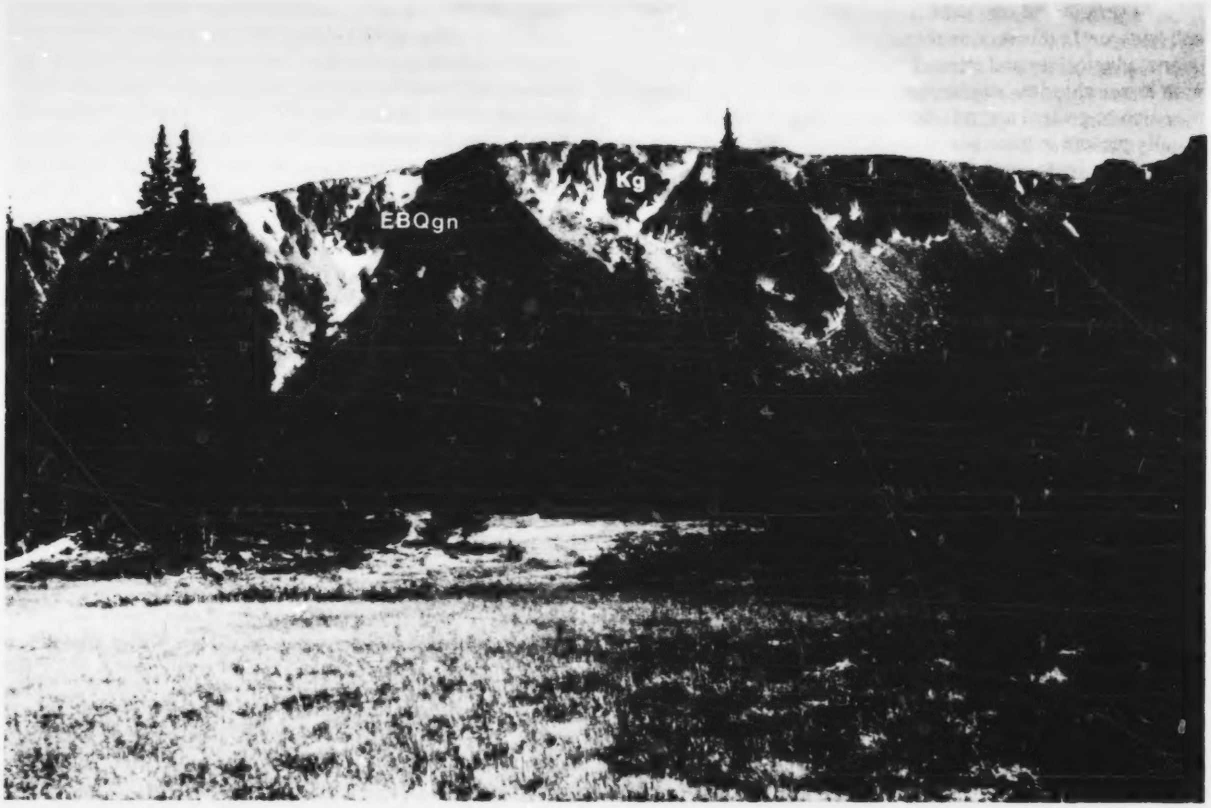

Plate 17. Contact between the Baldy batholith (Kg) and Unit EBQgn of the Eagle Bay Assemblage, Granite Mountain.

bearing pelitic rocks in the outer part of the aureole is generally indistinguishable from that outside the aureole. Contact metamorphic biotite from a pelitic rock within Unit EBA along the southwestern margin of the batholith is oriented parallel to the axial plane of east-west crenulations, suggesting that intrusion of the batholith was contemporaneous with these structures (*see* Chapter 3).

Granitic rocks exposed in the east central part of the map area, between East Barriere and Adams lakes, comprise the southeastern margin of the Baldy batholith, but may represent deeper levels that are partially detached from those to the northwest by the Barriere River fault. These rocks intrude Unit EBQ and orthogneiss of Unit Dgn in an area of relatively high regional metamorphic grade. Contacts are much more irregular and complex than they are to the northwest and contact metamorphic effects are not readily distinguished from the relatively high-grade regional metamorphism.

The Raft batholith extends across the north end of the map area but is partly obscured by overlying Miocene basalt along the Clearwater River valley. It consists mainly of light to medium grey, medium to coarse-grained hornblende biotite granodiorite (*see* modal analyses presented by Campbell and Tipper, 1971, page 73). East of Clearwater River valley, the southern margin of the batholith generally comprises a broad zone of intermixed country rock and granodiorite. Cordierite(?), andalusite and sillimanite were noted within quartz-muscovite-biotite schist of Unit EBQ at several localities within and south of this contact zone. West of the Clearwater River, where the batholith intrudes the Fennell Formation, the contact is more abrupt and well defined. Similar observations were made by Okulitch (1979) who noted that the batholith has steep discordant contacts west of the Clearwater River valley, but concordant inward-dipping contacts to the east. These relationships are in part due to Eocene, west-side-down normal faults along the Clearwater River (*see* Chapter 3). These result in exposure of higher levels of the intrusion on its west side.

The granitic stock exposed east of Robert Creek consists of massive granite with large amounts of pegmatite and some foliated granitic rocks. The latter may comprise screens of older intrusive rocks within the mid-Cretaceous granite.

LATE DYKES

Dykes and rare sills of unfoliated, light grey, chalky white-weathering quartz feldspar porphyry are common in the vicinity of Adams Plateau, where some are of sufficient size to be portrayed on the geological map (Unit qp). They consist of quartz, potassium feldspar and rare plagioclase phenocrysts within an aphanitic to very fine-grained quartzofeldspathic matrix. The dykes typically trend in a

Plate 18. Eocene(?) mafic dyke cutting Unit EBA quartz sericite phyllite, roadcut east of Birch Island on Highway 5.

northerly direction and dip steeply. Some appear to follow northerly trending (Tertiary ?) fault zones and one dyke cuts across the northeast-trending Nikwikwaia Creek fault without being offset. These relationships suggest that the dykes are Tertiary in age (*see* Chapter 3) although some may be related to nearby Cretaceous granite. Similar dykes, some with hornblende as well as quartz and feldspar phenocrysts, were noted elsewhere in the area; these are uncommon and too small to be shown on the geological map.

Steeply dipping, northerly trending dykes of basalt, diabase and lamprophyre also occur in the area (Plate 18). They are most common in the vicinity of the North Thompson River and Adams Lake valleys. They are probably of about the same age as the northerly trending Tertiary faults, which are also concentrated in these areas (Chapter 3).

CHAPTER 3

STRUCTURE

INTRODUCTION

The structural history of the area is summarized in Figure 14. The dominant structures are premetamorphic, easterly directed thrust faults which imbricate the Fennell Formation and separate it from Unit EBP and later synmetamorphic southwesterly overturned folds and associated thrust faults. These structures are cut by postmetamorphic northwest-trending mesoscopic folds and by later west-trending macroscopic and mesoscopic folds which are synchronous with intrusion of the mid-Cretaceous Raft and Baldy batholiths. The youngest structures recognized are northeast-trending strike-slip faults and later northerly trending faults and associated folds which are Eocene in age.

The earliest macroscopic structures recognized in the area are the more or less layer-parallel faults which imbricate the Fennell Formation and separate it from Mississippian clastic rocks of the Eagle Bay Assemblage. East-verging, premetamorphic mesoscopic folds within the Fennell Formation (Plate 19) probably formed during this period of faulting; they corroborate paleogeographic interpretations that the faults are easterly directed thrusts. There was no significant metamorphism and no development of foliation during this deformation. The contrast in stratigraphic facies across the basal Fennell thrust suggests that easterly translation of the oceanic Fennell terrane was many tens or even hundreds of kilometres.

Plate 19. East-verging premetamorphic fold in cherty argillite of the lower Fennell Formation, Joseph Creek.

Tectonic emplacement of the Fennell Formation was followed by synmetamorphic southwesterly directed folding and associated thrust faulting. This event gave rise to the dominant macroscopic structures within the map area such as the Slate Creek and Barriere anticlines, the Nikwikwaia syncline, and the northeast-dipping faults which separate major structural/stratigraphic belts within the area (Figure 6). The associated synmetamorphic schistosity, which grades to a slaty cleavage, or locally a gneissosity, is the dominant mesoscopic fabric element throughout the area. This schistosity is axial planar to generally tight to isoclinal folds that are outlined by bedding (Plate 20); locally, however, they fold an earlier metamorphic foliation. This early foliation is not associated with any known macroscopic structures. Bedding/schistosity intersections, mineral lineations and quartz rodding lineations formed during the synmetamorphic folding are parallel to the axes of the mesoscopic folds. These are somewhat variable in orientation, in part due to later deformation, but generally plunge northwest to east.

The southwesterly directed thrust faults, which are inferred to have formed in conjunction with the synmetamorphic southwesterly directed folding, appear to postdate most of the folds. These thrusts do not follow metamorphic discontinuities, but their precise relationship to the metamorphism is uncertain.

Synmetamorphic deformation was followed by the development of upright, northwest-plunging folds. These are common within the area from Clearwater to Adams Lake, but are not well represented on the east side of the lake. They occur mainly on the mesoscopic scale; larger folds with amplitudes up to several hundred metres occur locally, but do not appreciably affect the macroscopic geometry within the area. Development of these folds was accompanied by formation of a steeply dipping, northwest-striking crenulation cleavage parallel to their axial planes (Plate 21), and an axial crenulation lineation. These structures were not accompanied by any significant metamorphic recrystallization, rather they bend and fracture metamorphic minerals which crystallized during the earlier synmetamorphic deformation.

Intrusion of the mid-Cretaceous Raft and Baldy batholiths postdated the previously described structures and gave rise to

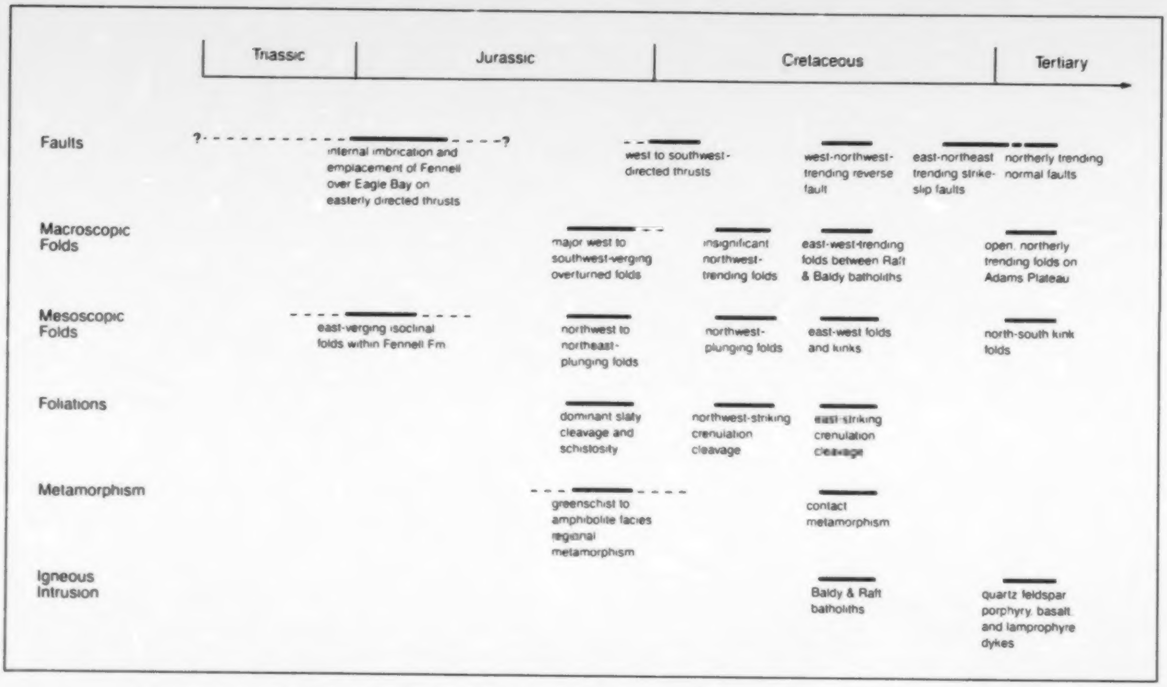
Triassic
Jurassic
Cretaceous
Tertiary
Faults
?
?
internal imbrication and emplacement of Fennell over Eagle Bay on easterly directed thrusts
west to southwest-directed thrusts
west-northwest-trending reverse fault
east-northeast trending strike-slip faults
northerly trending normal faults
Macroscopic Folds
major west to southwest-verging overturned folds
insignificant northwest-trending folds
east-west-trending folds between Raft & Baldy batholiths
open, northerly trending folds on Adams Plateau
Mesoscopic Folds
east-verging isoclinal folds within Fennell Fm
northwest to northeast-plunging folds
northwest-plunging folds
east-west folds and kinks
north-south kink folds
Foliations
dominant slaty cleavage and schistosity
northwest-striking crenulation cleavage
east-striking crenulation cleavage
Metamorphism
greenschist to amphibolite facies regional metamorphism
contact metamorphism
Igneous Intrusion
Baldy & Raft batholiths
quartz feldspar porphyry, basalt and lamprophyre dykes

Figure 14. Mesozoic-Tertiary structural history of the Adams Plateau – Clearwater – Vavenby area. Not shown is an early metamorphic foliation of Mesozoic and/or Paleozoic age.

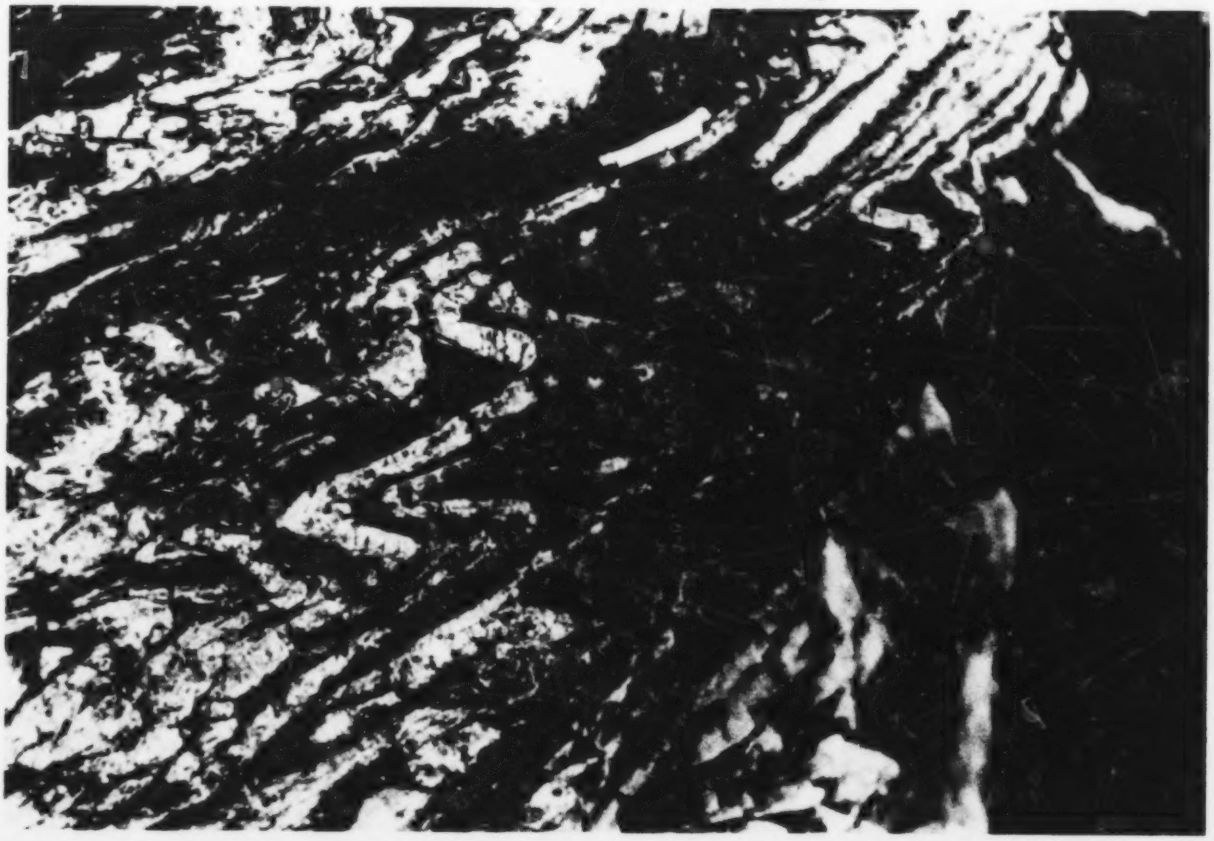

Plate 20. Synmetamorphic folds in thin-bedded quartzite and phyllite of Unit EBS, east end of Forest Lake.

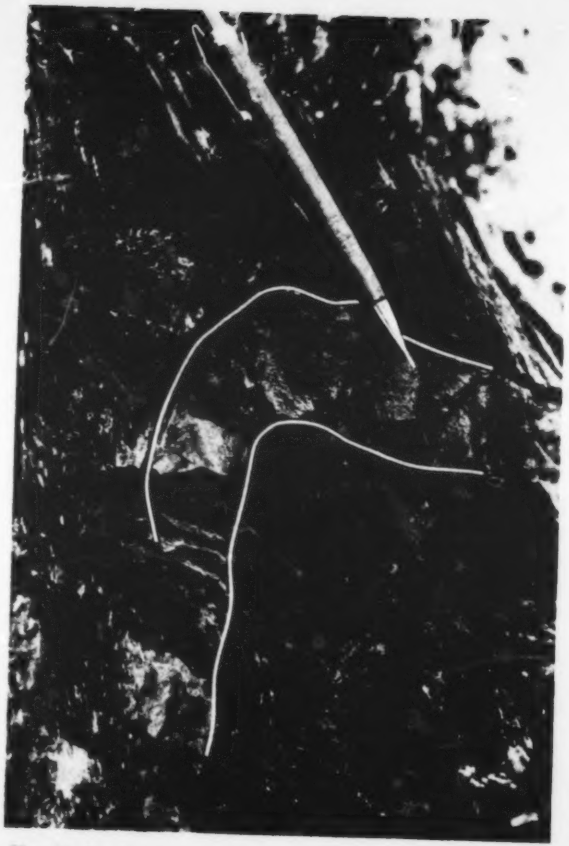

Plate 21. Northwest-plunging postmetamorphic fold with axial planar crenulation cleavage, Unit EBP slate and siltstone, Birk Creek area.

Plate 22. Quartz sericite phyllite of Unit EBA cut by northerly trending fractures and kinks of probable Eocene age, roadcut east of Birch Island on Highway 5.

west-trending macroscopic folds in the area between the plutons. A north-northeast-dipping reverse fault that extends west-northwest from a zone of folding on the northwest margin of the Baldy batholith may be of the same age. West-trending mesoscopic kink folds and an associated crenulation lineation, which are common between the Raft and Baldy batholiths, also formed at this time. Locally, within the metamorphic aureole of the Baldy batholith, contact metamorphic biotite is aligned parallel to the axial planes of the east-west crenulations.

West-trending folds and kinks, which have an associated crenulation lineation and steeply dipping, east-striking crenulation cleavage, are also common in the vicinity of Adams Lake and Adams Plateau. These are probably the same age as the mid-Cretaceous kink folds and crenulations spatially associated with the Baldy and Raft batholiths. Their occurrence in this area suggests that the west-trending folding event was regional in extent and not merely associated with the intrusion. The west-trending Baldy and Raft batholiths may have been localized along structures which formed at this time.

Northeast-trending faults appear to postdate all of the structures described in the preceding paragraphs and to be themselves truncated by northerly trending faults of Eocene age. They cause a number of abrupt offsets and discontinuities of structural and stratigraphic elements within the area, the most notable of which is the truncation of the Fennell Formation along Barriere River. These faults are predominantly strike-slip faults; most display right-lateral offset.

The youngest structures recognized are northerly trending faults and mesoscopic kink folds (Plate 22). These occur throughout the area, but are most common along the North Thompson River valley in the western and northern part of the map area, in the vicinity of Adams Lake, and on Adams Plateau in the southeast, where they are accompanied by a few broad open north-plunging macroscopic folds. One northerly trending west-side-down normal fault adjacent to the North Thompson River is known to be Eocene (or later) in age; this is considered the most likely age of all the late northerly trending structures.

The structural sequence described represents events that began in post-Middle Permian time (the youngest rocks involved in Fennell thrusting) and extended into Early Tertiary time. The main periods of synmetamorphic to postmetamorphic folding and associated faulting, which occurred prior to intrusion of the mid-Cretaceous Baldy batholith, are manifestations of the Jurassic-Cretaceous

Columbian orogeny. Easterly directed thrusting of the Fennell Formation probably preceded these events by a relatively short length of time, although similar thrusting of a Late Paleozoic oceanic terrane within the western United States was, in places, considerably older and took place in Permo-Triassic time (Silberling, 1973; Speed, 1977).

Paleozoic deformation is well documented within the Kootenay Arc on the east side of the Shuswap Complex (Read and Wheeler, 1976) and has been inferred to have also affected rocks in the region of the map area (Okulitch, 1979). No structures which could be unequivocally assigned to a Paleozoic deformation event were documented during the present study. Metamorphic foliations that predate the main synmetamorphic schistosity, which is associated with southwesterly directed folding in the area, were noted within Units EBH, EBG, EBQ and EBS of the Eagle Bay Assemblage. These could not be related to macroscopic structures and it is not known whether they are considerably older than the Mesozoic deformation which dominates the structural pattern of the area or simply an earlier manifestation of this event. Locally, the early foliation occurs within Unit EBQ but not within adjacent orthogneiss of Unit Dgn, suggesting that, at least in part, it is pre-Late Devonian in age. Pre-Middle Devonian deformation is supported by the apparent unconformable relationship of the Devono-Mississippian part of the Eagle Bay Assemblage to underlying rocks. Further evidence comes from the Fennell Formation where one chert sample (Appendix 1, Sample S13) contained, in addition to mildly metamorphosed Middle Permian conodonts, a suite of reworked Early Paleozoic conodonts which were subjected to a higher level of metamorphism than the Permian ones. If, as is suspected, the Fennell Formation accumulated in an oceanic basin directly outboard from the Eagle Bay terrane, these reworked Lower Paleozoic conodonts provide indirect evidence for Paleozoic deformation and metamorphism within the Eagle Bay Assemblage.

EASTERLY DIRECTED THRUST FAULTS

The earliest macroscopic structures recognized within the area are more or less layer-parallel faults which imbricate the Fennell Formation and separate it from Unit EBP. There is no evidence of metamorphism or cleavage development related to this period of thrusting. Movement on these faults must have been easterly directed in a general sense, as they juxtapose a deep-water oceanic assemblage, probably derived from a Late Paleozoic marginal basin situated outboard from the western North American continental margin, above rocks that were probably deposited on or near the western extension of the miogeocline. Easterly directed movement is corroborated by premetamorphic mesoscopic east-verging folds within the Fennell Formation which are inferred to have been coeval with the thrusting (Plate 19).

The most important of these early thrust faults separates the Fennell Formation from Unit EBP. Evidence for this fault is summarized as follows:

(1) Top determinations within both suites indicate that the Fennell Formation overlies Unit EBP, yet there is a total absence of mafic sills or dykes within Unit EBP that could be feeders to overlying Fennell basalts. This is all the more striking when it is noted that much of the lower division of the Fennell Formation is comprised of gabbro and diabase.

(2) From upper Birk Creek southwards to Sprague Creek, there is a truncation of Fennell Formation rock units (including a gabbro sill) along the Fennell-EBP contact (Figure 4). This truncation is supported by fossil data which indicate a decrease in the age of the lowest exposed Fennell rocks from Pennsylvanian in the north to mid-Permian in the south. These Fennell rocks directly overlie Unit EBP rocks that are known to be Early Mississippian in age.

(3) Where the contact is exposed in the vicinity of upper Birk Creek, it is marked by a zone of brecciation which appears to predate the synmetamorphic cleavage.

(4) Upper Mississippian conodonts within Unit EBP south of the Barriere River are younger than the Lower Mississippian conodonts found within the Fennell Formation in the vicinity of Joseph Creek; they are also younger (as is the lower Mississippian fauna within Unit EBP near the Enargite lead-zinc showing) than the Devonian radiometric age indicated for Fennell Formation quartz feldspar porphyry. Thus there are stratigraphic elements within the Fennell Formation which are older than elements within the structurally underlying rocks of Unit EBP.

Evidence for the early age of this fault derives from the identical metamorphic grade, bedding attitudes and bedding/synmetamorphic cleavage relationships within the Fennell Formation and immediately adjacent rocks of Unit EBP, which indicate that together they comprise the steeply dipping western limb of the Slate Creek anticline. Further evidence is provided by the fact that it is overridden by a westerly directed thrust fault north of the Baldy batholith (Figure 5, section A-A′).

Thrust faults within the lower division of the Fennell Formation are indicated by the older-over-younger relationships documented by fossil and radiometric ages within this west-facing panel of rocks. The available data require that the lower Fennell division comprises at least three and locally four fault slices, as is indicated in Figure 10. However, the stratigraphic and age control within the lower Fennell division is not strict enough to rule out the possibility of additional faults within this package. The faults within the lower Fennell occur entirely within the western limb of the Slate Creek anticline; they do not correspond to changes in metamorphic grade or to breaks in the pattern of bedding/synmetamorphic cleavage relationships. One fault is truncated by the westerly directed thrust fault north of the Baldy batholith, and one is folded through the syncline which occurs southeast of Blackpool. They are, therefore, early structures which are inferred to be of the same age or older than the basal fault which separates the Fennell package from Unit EBP.

An early easterly directed thrust fault is also inferred to separate the lower and upper structural divisions of the Fennell Formation because the only two age dates from within the upper division [Early (?) Pennsylvanian and Middle Permian respectively] indicate that, at least in part, it is the same age as the lower division. A fault at this position therefore seems probable as this contact is the most obvious lithologic break within the Fennell package. It is also possible that the upper Fennell is imbricated by faults similar to those within the lower division, but lack of stratigraphic and age control within these monotonous basalts has prevented their definition.

SYNMETAMORPHIC FOLDS

SLATE CREEK ANTICLINE

The Slate Creek anticline is a major west-verging fold which dominates the macroscopic structure of the map area between the Barriere River fault and Clearwater. The Fennell Formation and immediately adjacent elements of Unit EBP comprise the fold's steeply dipping to overturned western limb. Unit EBP occupies the fold's hinge zone throughout this length, but is only exposed south of the Baldy batholith and in a small fault block immediately south of Clearwater. Elsewhere the axial trace of the fold is truncated by the Baldy batholith or is covered by rocks of the structurally overlying fault slice (Figure 15; Figure 5, sections A-A′ and C-C′). The fold's gently dipping eastern limb is likewise only locally represented (by eastern exposures of Unit EBP) due to truncation by this overlying fault.

The Slate Creek anticline is outlined by contrasting bedding orientations, facing directions and bedding/synmetamorphic cleavage relationships on its opposing limbs. The western limb (forelimb) is characterized by steeply dipping, west-facing bedding, cut by a less steep, generally east-dipping slaty cleavage or schistosity (Plate 23). These relationships persist throughout the Fennell Formation and in immediately adjacent rocks of Unit EBP. Their persistence across the faulted Fennell-EBP contact indicates that the fault is an early prefolding structure. The east limb of the anticline is characterized by gently dipping, right-way-up bedding that is essentially parallel to the synmetamorphic cleavage or schistosity; locally, however, the bedding is steepened by later upright northwest-plunging folds.

Plate 23. Overturned chert and slate of the lower Fennell Formation, south of Clearwater. View is to the south and bedding dips more steeply east than synmetamorphic slaty cleavage (parallel to hammer head). These bedding/cleavage relationships characterize the entire Fennell belt since it occupies the western limb of the Slate Creek anticline.

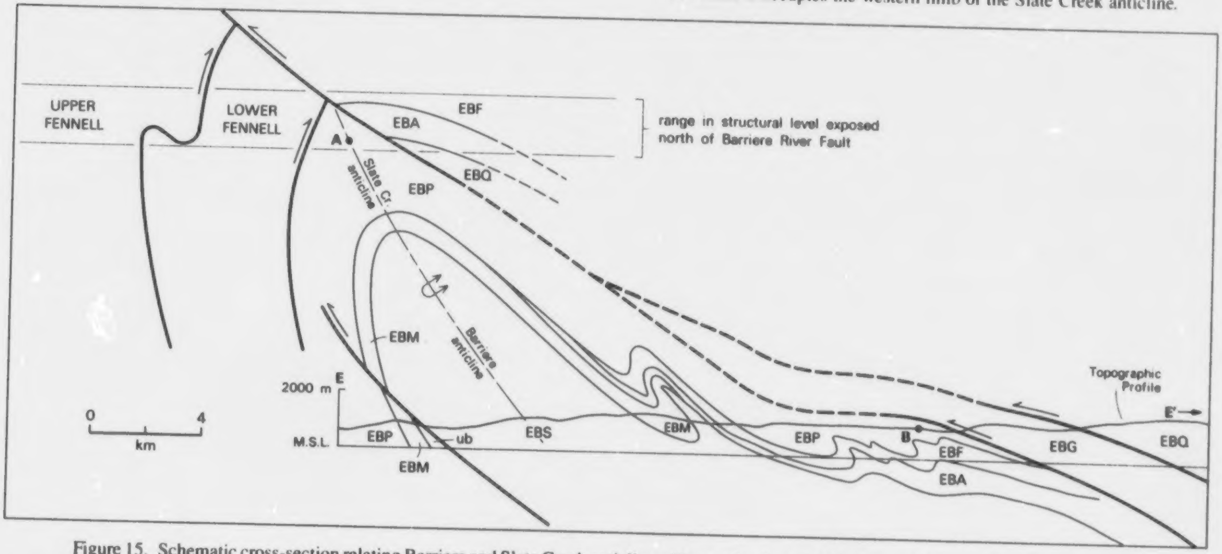

Figure 15. Schematic cross-section relating Barriere and Slate Creek anticlines. The section line (E-E′ of Figure 4) is south of the Barriere River fault and crosses the Barriere anticline which hinges in Unit EBS. The projected higher structural level of the fold, where it hinges in Unit EBP, is equivalent to the Slate Creek anticline as exposed north of the Barriere River fault. Projection of this higher structural level into the Barriere River fault indicates an offset of 15 to 20 kilometres along a slip vector pitching 20° to 30° northeast for its counterpart (the Slate Creek anticline) north of the fault. The offset is schematically illustrated by points A and B, which are points on the structure juxtaposed directly opposite one another, north and south of the fault respectively (*see* Figure 4).

Bedding/synmetamorphic cleavage relationships within Unit EBP between the Baldy batholith and the Barriere River fault, and within the small fault block of Unit EBP rocks directly south of Clearwater, indicate that the Slate Creek anticline hinges within Unit EBP throughout this area. In many places the axial trace is not well constrained; it appears to migrate toward the Fennell-EBP contact from south to north along the belt, suggesting that overall the fold has a shallow northerly plunge. This is consistent with the plunge of the synmetamorphic mesoscopic fold axes and lineations in this part of the map area.

The Rennie Creek syncline is a medium-scale fold occurring within the Fennell Formation on the west limb of the Slate Creek anticline, east of the North Thompson River at Blackpool (Figure 5, section A-A′). The fold is outlined by a conglomerate horizon and cored by metabasalt within the uppermost fault slice of the lower Fennell. It is probably part of a parasitic anticline-syncline pair which formed within the forelimb of the kinematically associated Slate Creek anticline (Figure 15). Presumably the anticlinal half of this inferred fold pair has been cut out by west-side-down normal faulting along the North Thompson River (Figure 5, section A-A′).

BARRIERE ANTICLINE

The Barriere anticline is a major southwesterly overturned fold which occurs in the southwestern quadrant of the map area. Its axial trace lies entirely within Unit EBS; it is truncated on the north by the Barriere River fault and to the south by the northeast-dipping fault and serpentinite belt in the vicinity of North Cicero Creek. The anticline repeats a distinctive limestone unit (EBSc) and pillowed basalt unit (EBSb) within Unit EBS along the northern part of the belt (Figure 5, section D-D′). It also results in other symmetries within Unit EBS, such as the occurrence of metatuff horizons (in part EBSt), mainly along the extreme northeast and southwest margins of the belt. On a larger scale, the fold repeats Units EBM and EBP which overlie Unit EBS to the northeast and structurally underlie it to the southwest (Figure 5, section E-E′). These rocks are in part faulted against Unit EBS along the southwestern margin of the map area, but north of Fadear Creek, bedding/schistosity relationships within Unit EBP suggest that Units EBM and EBP are overturned and comprise a faulted continuation of the southwestern limb of the anticline.

The trace of the axial surface of the anticline is generally poorly constrained. At the north end of the belt it lies between the opposing portions of the limestone-metabasalt succession which it repeats, while to the south, as far as Forest Lake, the trace is moderately well defined by changes in bedding/schistosity relationships and associated mesoscopic fold asymmetry. A few top determinations provided by graded beds within Unit EBS confirm that the strata on the northeast limb are right-way-up, but no evidence for way-up was found on the southwestern, presumably overturned, limb. South of Forest Lake the axial trace is not well constrained, but is projected along the general trend established to the north, until it is truncated by the fault/serpentinite belt. The hinge zone of the anticline is apparently very narrow and may in part be faulted.

A southwest-verging medium-scale anticline-sycline pair, outlined by a metatuff horizon (EBSt) in the vicinity of Sinmax and Johnson creeks, is parasitic on the northeast limb of the Barriere anticline (Figure 5, section E-E′). Unit EBM is preserved within the synclinal portion of the fold pair. Similar westerly verging folds may exist within Unit EBP farther to the northeast and explain the anomalous outcrop width of this unit, as indicated diagramatically in cross-section E-E′ (Figure 5). A synclinal fold which overturned the Rea mineral deposit may be part of this system, although this fold may be more directly related to southwesterly directed thrusting of structurally overlying EBG rocks.

Unit EBP, which occupies the hinge zone of the Slate Creek anticline on the north side of the Barriere River fault, is repeated on the limbs of the Barriere anticline at the lower structural and stratigraphic levels exposed south of the fault. The axial traces of the two anticlines are separated by approximately 13 kilometres along the fault. It seems very likely that the Barriere anticline is the southward extension of the Slate Creek anticline at a markedly lower structural level, and that this large anticlinal structure has been displaced by more than 13 kilometres of oblique (north-side-down) right-lateral strike-slip faulting along the Barriere River fault. Figure 15, a diagramatic section drawn along the same line as section E-E′ of Figure 4, demonstrates this relationship.

NIKWIKWAIA SYNFORM

The Nikwikwaia fold is a northerly dipping isoclinal synform cored by Unit EBGs metasediments and enclosed within Unit EBG chlorite schists on the Adams Plateau (Figure 5, section G-G′). A relatively pure quartzite horizon (EBGq) occurs locally along the metasediment – chlorite schist contact and helps outline the fold. The quartzite wraps around the fold nose in the vicinity of Nikwikwaia Lake, from where the belt of metasediments in the core of the fold extends and broadens eastward to beyond the limits of the map area. The belt is cut and gently warped by northerly trending faults and folds; its southern contact is displaced by approximately 3 kilometres of right-lateral offset along the northeast-trending Nikwikwaia fault. The Nikwikwaia synform is probably a syncline as the metasediments in its core are enclosed by chlorite schists which underlie them regionally. The syncline is inferred to be flanked to the north by an anticline which is necessary to re-establish the normal (presumably northerly) facing direction within the Unit EBG belt. The anticline occurs entirely within chloritic schists which suggests that the metasediments coring the Nikwikwaia syncline are lensoid and discontinuous to the north and/or that the anticlinal hinge is largely cut out by layer-parallel shearing near the base of the Tshinakin limestone. The anticline-syncline pair comprises a southerly verging fold system, consistent with the general sense of tectonic transport within the map area.

SOUTHWESTERLY DIRECTED THRUST FAULTS

VAVENBY FAULT

The Vavenby thrust fault occurs between the Raft and Baldy batholiths, where it separates Units EBG and EBH of the fourth fault slice from underlying rocks of the third slice. Upper-slice rocks are exposed on both sides of the North Thompson River. South of the river, especially in the area between Robert and Baker creeks, they occur in a number of fault blocks bounded by late northerly to northeasterly trending faults. Within this area, the Vavenby fault and the footwall and hangingwall successions dip mainly to the north; locally, where the fault is folded through late west-trending synforms, it dips to the south (Figure 5, section H-H′). North of the North Thompson River, however, the fault dips east to northeast. The predominant westerly strike is probably controlled by mid-Cretaceous east-west folding between the Raft and Baldy batholiths rather than reflecting the original orientation of the thrust.

Unit EBG and EBH rocks above the Vavenby thrust are overturned and are inferred to comprise the lower limb of a large nappe structure (Figure 5, section H-H′). This fold may have formed during the period of synmetamorphic, southwesterly directed folding that gave rise to other major folds in the area, such as the Slate Creek and Barriere anticlines and the Nikwikwaia synform. Latest movement along the Vavenby thrust apparently postdates the folding, because west of Chuck Creek the thrust truncates Unit EBH rocks that are inferred to comprise the core of a medium-scale anticline, interpreted to be the same age as the major fold structure. Elsewhere in the area Unit EBG lies directly above the inferred position of the fault trace. Over most of the area Unit EBG lies above Unit EBP; east of the Chuck Creek fault however, it locally lies above either Unit EBA or Unit EBQ. This pattern suggests that from east to west, the thrust cuts gradually up-section through the footwall succession.

BIRK CREEK FAULT

The Birk Creek thrust fault separates rocks of the third Eagle Bay fault slice from underlying rocks of the first and second slices. South of the Barriere River strike-slip fault, it extends from Adams Lake northwestward to North Barriere Lake and brings together Unit EBQ of the third slice and Unit EBG of the second slice. The thrust presumably dips to the northeast, as do underlying rocks of Unit EBG. The hangingwall succession, comprising Unit EBQ underlain by Devonian orthogneiss (Unit Dgn), dips southwest into the fault surface (Figure 5, section E-E′; Figure 6).

North of the Barriere River fault, the Birk Creek thrust dips to the east and juxtaposes Units EBQ, EBA and EBF of the third fault slice with either Unit EBP or the Fennell Formation, which occur within the upper part of the first fault slice. South of the Baldy batholith the thrust brings rocks of the third slice against Unit EBP. It truncates the EBQ/EBA contact in its hangingwall and cuts up-section from south to north through the footwall of the flat-lying east limb of the Slate Creek anticline. Consequently it impinges upon the axial trace of the fold immediately south of the batholith. At structural levels exposed immediately north of the batholith, the fault over-rode the axial trace and the folded EBP/Fennell contact, and placed flat-lying rocks of the third fault slice against steeply dipping Fennell strata on the west limb of the anticline (Figure 5, section A-A′). To the north, progressively lower levels of the Fennell package (including an early easterly directed thrust) gradually appear from beneath the fault trace. South of Clearwater, displacement across the northeast-trending Blackpool fault causes an abrupt drop to even lower structural levels, so that the Birk Creek thrust once again has Unit EBA above Unit EBP, as it does south of the Baldy batholith. The thrust can be traced northward across a late northwest-trending fault within the North Thompson River valley. On the north side of the river Unit EBQ is in the hangingwall and Fennell Formation in the footwall. It is covered by Miocene basalt a short distance north of the river, but may persist to the northwest into the Bonaparte Lake map area where, north of the Raft batholith, Campbell and Tipper (1971) mapped an east-dipping thrust fault with footwall Fennell Formation and hangingwall rocks that may be equivalent to Unit EBQ.

HAGGARD CREEK FAULT

The Haggard Creek thrust fault separates Unit EBG rocks of the second fault slice from underlying Devono-Mississippian rocks of the first slice. This northeast-dipping fault extends from Barriere River, where it is truncated by the Barriere River fault, to the Adams Plateau. Truncation of the footwall succession occurs along the fault and, from northwest to southeast, Unit EBG sits progressively above Units EBP, EBF and EBA. Truncation is most abrupt within Unit EBF southeast of the Rea showing, where the fault cuts out the overturned syncline which may have formed during the early stages of thrusting (Figure 5, section F-F′). The gradual pinch-out of mafic metavolcanic rocks of Unit EBG eastward across the Adams Plateau may also be due to truncation against the underlying thrust fault.

Rocks of the second fault slice do not occur north of the Barriere River fault. There the third fault slice sits directly on the first and Unit EBG is inferred to have pinched out between the underlying Haggard Creek and overlying Birk Creek faults. The truncation is not seen as there is an abrupt change in structural level across the Barriere River fault.

CICERO CREEK FAULT

The Cicero Creek fault, which is in part marked by a serpentinite belt, separates Unit EBS from structurally underlying EBM and EBP rocks on the southwest limb of the Barriere anticline. It is a relatively minor structure within the fourth fault slice. It is, however, inferred to be a thrust fault similar to those that separate major structural slices in the area. Displacement apparently increases southeastward and beyond the limits of the map area. In that direction it marks a rapid thinning of Unit EBS, presumably due to structural truncation.

EASTERLY TRENDING FOLDS

Upright easterly trending macroscopic folds are common in the area between the Raft and Baldy batholiths and cause reversals in the predominantly northerly dips of bedding and schistosity. The most conspicuous of these is the Graffunder Lakes synform which deforms rocks within the third and fourth fault slices, and also the intervening Vavenby thrust fault, in the area east of the Chuck Creek fault (Figure 5, section H-H′). A west-trending anticline which extends from just south of Mount McClennan to the North Thompson River west of Birch Island is also of significant size (Figure 5, section I-I′). Similar but less extensive dip reversals occur across easterly trending synformal hinges in the vicinity of Jones Creek and on the slopes north of the North Thompson River between Crossing and Peavine Creeks (Figure 4).

An upright gently westward-plunging antiform occurs north of the Baldy batholith near Granite Mountain, where it folds relatively flat-lying Eagle Bay rocks of Units EBQ, EBA and EBF. The fold does not have any significant expression in adjacent steeply dipping rocks of the Fennell Formation, probably because the Fennell and Eagle Bay were highly discordant prior to the onset of east-west folding. To the west of this anticline, however, overturned lower Fennell strata dipping steeply east, deflect through a synformal hinge to attain moderate northwesterly dips on the northwest flank of the batholith (section D-D′ of Schiarizza, 1983). The axial surface of this north-northwest-plunging fold dips at moderate angles to the north-northeast. The lower part of the southern limb of the synform is very gradually truncated to the southwest, along the margin of the batholith. Higher levels to the northwest are truncated by the Joseph Creek stock. Equivalent strata south of the stock strike northerly and dip steeply west, after having passed through a complementary antiformal hinge which is in large part masked by the stock and by late northerly trending faults. The synformal and antiformal axial surfaces appear to converge to the northwest, where they pass into a northeast-dipping reverse fault which is probably coeval with the folding.

Clearly the folds described in the previous paragraph were generated during emplacement of the Baldy batholith. The easterly trending folds between the Baldy and Raft batholiths are probably also related to their intrusion. Mesoscopic easterly trending kink folds, which are common between the batholiths and in places along the south margin of the Baldy batholith, also formed at this time and locally have contact metamorphic biotite oriented parallel to their axial surfaces. However, easterly trending mesoscopic folds are also common along the shores of Adams Lake and on Adams Plateau. Their presence far removed from the Baldy and Raft batholiths suggests that east-west folding was of regional extent and probably played a role in controlling emplacement of batholiths, which in turn were a direct cause of folds between them and along their margins.

NORTHEASTERLY TRENDING FAULTS

Northeast-trending faults are common throughout the area. They cause abrupt discontinuities and offsets in the generally northwesterly trending structural and stratigraphic grain. Movement along these faults was largely strike-slip; right-lateral offsets predominate although the opposite sense of displacement also occurs.

The largest of these, the Barriere River fault, traces along Barriere River for approximately 11 kilometres east of Barriere, from where it cuts across the wooded slopes south of Sprague Creek into the valleys of North Barriere River and North Barriere Lake. The western part of the fault marks the southern termination of the Fennell belt where it is juxtaposed against Unit EBS and the axial trace of the Barriere anticline. Farther east, the fault places Unit EBP in the hinge zone of the Slate Creek anticline against east-dipping EBP rocks on the eastern limb of the Barriere anticline and structurally overlying rocks of Unit EBG. The axial trace of the Slate Creek anticline is offset by about 13 kilometres from that of the Barriere anticline. These two folds are believed to be the same structure, but at markedly different structural levels; the actual displacement may be in the order of 15 to 20 kilometres along a slip vector which pitches 20 to 30 degrees eastward, as is schematically illustrated in Figure 15. This offset is considered reasonable as it compares closely with that derived from the simple observation that the 12-kilometre-wide belt of steeply dipping Fennell rocks is completely truncated by the fault. There is little apparent offset of Unit EBP across the fault in the vicinity of North Barriere River but this is deceiving as this unit occurs within the hinge zone of the anticline on the north side of the fault, and on the eastern limb of the fold on the south side. The small apparent offset indicates that movement on the Barriere River fault was along a slip vector pitching eastward within the fault plane at an angle comparable to the dip of the strata on the eastern limb of the fold. This slip direction is consistent with the significant north-side-down and right-lateral strike-slip displacement.

The Barriere River fault is apparently truncated, at the town of Barriere, by a northerly trending fault within the North Thompson River valley. Motion along this system of northerly trending faults is known to be as recent as Eocene (Schiarizza, 1982). To the east, the Barriere River fault may branch into a number of splays beneath and to the north of East Barriere Lake. The main fault, however, trends along the valley of North Barriere Lake. It appears to cut mid-Cretaceous granitic rocks of the Baldy batholith as its projected trace corresponds with an abrupt truncation of a southern lobe of the batholith and with a discontinuity in the aeromagnetic pattern (Aeromagnetic Map Series, Map 5321G, Barriere Lakes, Geological Survey of Canada/B.C. Ministry of Energy, Mines and Petroleum Resources). Movement along the Barriere River fault and other northeast-trending strike-slip faults in the area is therefore probably late Cretaceous or early Tertiary in age.

Other northeast-trending faults which show significant displacement include the Nikwikwaia Creek fault on Adams Plateau, a fault just to the northeast of Johnson Creek between South Barriere Lake and Sinmax Creek, and a fault which extends northeastward from Blackpool near the northern edge of the map area. The Blackpool fault displays 2 to 3 kilometres of oblique (south-side-down) left-lateral strike-slip displacement. Like the Barriere River fault it is truncated to the west by an Eocene(?) normal fault within the North Thompson River valley.

NORTHERLY TRENDING FAULTS

Northerly trending faults, some with documented Eocene or later west-side-down normal displacement, are the youngest structures commonly observed within the map area. These occur mainly within and adjacent to the North Thompson River valley and in the vicinity of Adams Lake and Adams Plateau.

One of these faults, in places marked by a brecciated zone several metres wide, can be traced for 6 kilometres along a trend of 020 degrees, from Dunn Lake to Joseph Creek. It cuts the upper Fennell Formation for most of this distance, but in the vicinity of Dunn Lake it marks the eastern boundary of an outlier of Eocene (Kamloops Group) sedimentary and volcanic rocks. These rocks dip at 35 to 40 degrees eastward into the fault (Figure 5, section B-B′), suggesting that they have been tilted during west-side-down movement along this apparently listric normal fault. Thus latest movement on the fault was Eocene or later.

A west-side-down normal fault striking 020 degrees also occurs within the North Thompson River valley from the latitude of Lemieux Lake to the north end of the study area, from where it continues northward along the Clearwater River valley. It truncates the gently east-dipping west limb of the Rennie Creek syncline in the lower Fennell Formation southeast of Blackpool, and juxtaposes it against west-dipping upper Fennell rocks exposed to the west of the river (Figure 5, section A-A′). This fault probably cuts the Raft batholith north of the map area, explaining the observations of Okulitch (1979) who noted that the batholith has steep discordant (presumably high-level) contacts west of the Clearwater River, but concordant inward-dipping contacts east of the river. Within the Clearwater River valley, the fault trace is overlain by apparently unfaulted Miocene volcanics (Campbell and Tipper, 1971).

Northerly trending faults are common in the area between Clearwater and Vavenby where they offset portions of both the Raft and Baldy batholiths. Many of these display right-lateral offsets. A west to northwest-trending fault occupies the North Thompson River valley in this area and places relatively low stratigraphic levels on the north side of the river against higher levels on the south (Figure 5, section I-I′). This fault apparently offsets northerly trending faults on opposite sides of the valley and may be the youngest structure recognized in the area.

Most of the northerly trending faults on Adams Plateau show relatively minor amounts of apparent right-lateral offset, suggesting some combination of right-lateral strike-slip and/or east-side-down normal movement. They are accompanied by broad, open, gently north-plunging folds and are locally intruded by quartz feldspar porphyry dykes (Unit qp).

The largest northerly trending fault in the area is the Louis Creek fault which occupies the Louis Creek, North Thompson River and Lemieux Creek valleys along the western edge of the map area. This fault separates the Eagle Bay and Fennell rocks of the Adams Plateau – Clearwater – Vavenby map area from Late Paleozoic and Mesozoic rocks of the Intermontane Belt (Quesnel terrane) to the west. Major movement along the Louis Creek fault zone had apparently ended prior to mid-Cretaceous time as the fault zone is cut by the Raft batholith (Campbell and Tipper, 1971). Latest movement along at least parts of this zone is, however, of Eocene age.

CHAPTER 4

MINERAL DEPOSITS

INTRODUCTION

Rocks within the map area host a large number and wide variety of mineral deposits, most of which were not examined in detail during the present study. However, their general characteristics and the structural and stratigraphic framework established by the study allow the most important deposits to be grouped as outlined in Table 1.

Type 1 deposits are stratabound, massive to semimassive sulphides containing mainly silver, lead and zinc. Most of them occur on Adams Plateau where they are hosted by a succession consisting of siliceous and graphitic phyllite, limestone and calc-silicate rocks (Unit EBGs) within the dominantly mafic volcanic package of Unit EBG. Similar deposits occur in the vicinity of Mount McClennan (Red Top, Snow and Sunrise showings) within a lithologically similar succession of rocks in the upper part of Unit EBQ. The two mineralized intervals are tentatively correlated (Figure 7) and are probably of early Cambrian age.

Type 2 deposits consist mainly of disseminated pyrite-pyrrhotite-chalcopyrite mineralization. The Harper Creek deposit, with inferred reserves of 90 million tonnes grading 0.4 per cent copper, is the main representative of this type of mineralization; similar mineralization occurs at the Lydia, EBL, VM and VAV showings. These showings occur within the third Eagle Bay fault slice, in Unit EBA or underlying rocks of Unit EBQ. In all cases the mineralized rocks are intruded by Devonian orthogneiss of Unit Dgn. Although the mineralization has been remobilized during Mesozoic and Tertiary events it is probably Devonian in age and related to intrusion of the orthogneiss.

Type 3 deposits comprise polymetallic precious and base metal-bearing massive sulphides, sometimes with barite, within Devono-Mississippian felsic to intermediate metavolcanic rocks of Units EBA and EBF. They include the Homestake occurrence and a number of smaller showings within the same belt between Johnson Creek and Squaam Bay; the Beca and Joe prospects on the southeast shore of Adams Lake; the Copper Cliff, Rainbow, CC, May, Broken Ridge and Harper properties in the Birk Creek area; and the recently discovered Rea deposit which occurs within Unit EBF southwest of Johnson Lake. The Fortuna showing, which is hosted by a felsic volcanic lens within Unit EBS metasediments near the junction of Fraser and Louis creeks, also appears to be of this type. There is potential for similar mineralization within Devonian felsic volcanic rocks of the Fennell Formation, but none has been discovered to date.

Type 4 mineralization is represented by the Rexspar and Bullion deposits. It comprises uranium-thorium-bearing

Table 1. Mineral Deposits (excluding veins) of the Adams Plateau — Clearwater — Vavenby Area

Deposit Type	Potential Commodities	Rock Association	Examples
1. Stratabound massive to semimassive sulphides within metasedimentary rocks	Ag, Pb, Zn	Early Cambrian graphitic and siliceous phyllite, limestone, quartzite, calc-silicate schist and chlorite schist of Units EBGs (Adams Plateau) and EBQ (Mt. McClennan)	Lucky Coon, Elsie, King Tut, Mosquito King, Spar, Pet, Red Top, Snow, Sunrise
2. Disseminated sulphides associated with Devonian intrusive rocks	Cu, Mo	Units EBQ and EBA adjacent to Devonian orthogneiss of Unit Dgn	Harper Creek, EBL, Lydia, VM, VAV, CW(?)
3. Volcanogenic massive sulphides	Au, Ag, Zn, Pb, Cu, barite	Devono-Mississippian intermediate to felsic metavolcanic rocks of Units EBA and EBF	Homestake, Rea, Beca, Joe, Birk Creek showings
4. Pyrite-fluorite replacement	U, fluorspar	Devono-Mississippian trachytic volcanic and intrusive rocks of Unit EBFt	Rexspar, Bullion
5. Volcanogenic massive sulphides	Cu, Zn, Co	Pennsylvanian-Permian oceanic basalt of the Fennell Formation	CC (Chu Chua)

pyrite-fluorite replacements associated with trachytic intrusive and extrusive rocks of Unit EBF, on the east side of Foghorn Creek.

Type 5 mineralization consists of massive cupriferous pyrite within oceanic basalts of the Fennell Formation. This type of mineralization is well represented only by the CC deposit within the upper Fennell Formation just east of Chu Chua Mountain. A small copper-magnetite showing in upper Fennell basalts on lower Newhykulston Creek may be of similar origin.

Most other deposits in the area are veins, although small pods of skarn mineralization occur locally near Cretaceous and Devonian granitic intrusions. The vein deposits contain mainly silver-lead-zinc mineralization, but the Windpass, Sweet Home and Gold Hill prospects are gold-bearing veins, and molybdenum-bearing veins occur adjacent to the Baldy batholith at the Judy showings.

1, 2. REXSPAR (82M-021), BULLION (82M-034)

The Rexspar deposit, outcropping on the slopes east of Foghorn Creek 5 kilometres south of Birch Island, comprises uranium-thorium and fluorite mineralization within a trachytic intrusive-extrusive complex (EBFt) of Unit EBF. The Rexspar area has received intermittent attention since 1918. Early interest was directed toward lead-silver and fluorite mineralization and, in the late 1920s, toward a bog manganese occurrence just north of the main mineralized area. Further work on the fluorite mineralization during the 1940s led to the discovery of uranium in 1949. The property was acquired by its present owner, Consolidated Rexspar Minerals & Chemicals Ltd., in 1951; three zones of uranium-thorium mineralization and one contiguous zone of fluorite mineralization were outlined by underground work and diamond drilling carried out in the early to mid-1950s and between 1969 and 1976. Combined reserves for the three zones of uranium mineralization are estimated at 1 114 158 tonnes grading 0.773 kilogram of U_3O_8 per tonne. In 1982 Placer Development Limited optioned the property and drilled a 540-metre hole to test for molybdenum mineralization at a deeper level within the Rexspar system, but obtained no encouragement. The following brief description of the deposit is taken largely from earlier reports by Preto (1978a; 1978b).

The host rock to the Rexspar mineralization (Unit EBFt) is a rusty weathering, light grey, pyritic, alkali feldspar porphyry comprising megacrysts of albite and potassium feldspar set in a fine-grained matrix of feldspar (mainly or entirely albite) and sericite. The rock ranges from massive to strongly foliated and in places includes coarse breccia. Rocks included within Unit EBFt outside the main mineralized zones comprise yellowish to rusty weathering pyritic sericite-albite-quartz schists and albite sericite schists which locally contain relict phenocrysts of albite and/or potassium feldspar. Lithic clasts, generally of similar composition to the enclosing schists, are common. The entire sequence appears to comprise a pile of lithic tuff and breccia largely of trachytic composition, but including some rhyolite and dacite members, which in the vicinity of the mineralization includes some intrusive phases. The presence of intrusive rocks and coarse breccias suggests that the area is close to a volcanic centre or vent.

Ore-grade uranium-thorium mineralization occurs in three separate lenses that are up to 20 metres thick and 140 metres long, and more or less conformable with the schistosity in the host rock. Mineralization within these lenses consists mainly of dark-coloured patches of fluorphlogopite-pyrite replacement that is commonly accompanied by lesser amounts of fluorite and calcite. Mineralization appears to have been subjected to the same deformation history as the surrounding rock. The principal uranium-thorium minerals are uraninite, thorian uraninite, torbernite, metatorbernite, thorianite and thorite; in addition, some uranium and thorium occur in monazite and niobian ilmenorutile, and rare earths are present in substantial amounts in bastnaesite and monazite. The uranium-thorium minerals occur either as tiny discrete grains inside the fluorphlogopite flakes or as discrete grains scattered in the pyrite-fluorphlogopite matrix. Fluorite is commonly found in the uranium-thorium lenses, but occurs mainly within a separate lens which is partly surrounded by the three lenses of potentially commercial-grade uranium-thorium mineralization (*see* Figure 2 of Preto, 1978b). Mineralization at Rexspar is probably syngenetic with the host rocks and derived from deuteric, volatile-rich fluids generated late in the evolution of the intrusive-extrusive complex represented by Unit EBFt.

The Bullion showing is located on Lute Creek, approximately 3.5 kilometres east of Rexspar. Uranium mineralization within Unit EBFt is similar to that at Rexspar, but is less extensive and of lower grade.

3. FOGHORN (82M-040)

The Foghorn showing consists of sulphide-bearing quartz veins which cut feldspathic schists of Unit EBF on Foghorn Mountain. It was discovered in the early 1900s; development work completed at that time included an adit, several shafts, and numerous pits and trenches. Seventy-three tonnes of ore, yielding 88 366 grams of silver and 25 981 kilograms of lead, were shipped from the property in 1916-17. The area was explored by Consolidated Rexspar Minerals & Chemicals Ltd. in 1958 and more recently by Craigmont Mines Limited who drilled a hole over the old underground workings in 1980. The property is currently owned by MFC Mining Finance Corporation (formerly Consolidated Barrier Reef Resources Limited) and optioned to Esso Minerals Canada.

The underground workings at the Foghorn showing are now inaccessible. The host rock is rusty weathering greenish grey feldspathic schist of Unit EBF which dips at moderate angles northward. Mineralized material in the dumps comprises galena, pyrite, sphalerite and chalcopyrite together with abundant quartz. Brewer (Minister of Mines Annual Report, 1915, pages 220-221) stated that the mineralization occurrs in a few narrow quartz veins, the widest being 36 centimetres, with northeasterly strikes and variable northwest to southeast dips. Sulphide-bearing quartz veins reportedly also occur 1 kilometre to the north at the Chidgrin showing and 1.2 kilometres to the southeast at the Kelly showing.

4. JUDY (92P-036)

The Judy (Judy 4) showing consists of molybdenite-bearing quartz veins cutting hornfelsed lower Fennell rocks adjacent to the Baldy batholith, approximately 2 kilometres north of Baldy Mountain. The mineralization is exposed within a rusty interval several metres wide, containing both mineralized and barren quartz veins ranging from 1 to 15 centimetres wide. The molybdenite occurs as sparsely scattered coarse flakes sometimes accompanied by pyrite. Similar mineralization is reported at the Line showing 1 kilometre to the southwest, and at the Judy 11 showing 2 kilometres to the south (Reeve, 1966, Assessment Report 1047). Chalcopyrite reportedly accompanies molybdenite at the Judy 11 showing.

5-7. WINDPASS (92P-039), SWEET HOME (92P-040), GOLD HILL (92P-041)

The Windpass and Sweet Home mines, both former producers, worked gold-bearing quartz veins which cut the Fennell Formation east of Dunn Lake, approximately 2 kilometres west of the Baldy batholith. The mineralization was discovered in 1916; ore produced intermittently between then and 1944 (mainly from 1934 to 1940) amounted to a total of 93 435 tonnes yielding 1 071 684 grams of gold, 53 469 grams of silver and 78 906 kilograms of copper. Both the Windpass and Sweet Home veins, which dip at variable angles to the north, cut the western margin of a steeply west-dipping diorite sill and an adjacent bedded chert horizon within the lower Fennell Formation, directly east of the upper Fennell contact. Uglow (1922) reported that the Windpass vein ranges from several centimetres to almost 1 metre in width while the Sweet Home vein, 800 metres to the south, is between 20 and 38 centimetres wide. The quartz contains variable amounts of pyrite, chalcopyrite, bismuth, free gold and, at Windpass, magnetite and gold tellurides.

Gold also occurs at the Gold Hill showing approximately 2.5 kilometres southwest of Sweet Home. The mineralization occurs within generally east-trending, rusty ferrodolomite zones up to several metres in width, which cut upper Fennell basalts. The ferrodolomite zones contain irregular pods, veins and breccia fragments of quartz locally mineralized with pyrite, galena, chalcopyrite and sphalerite. Gold reportedly occurs within both the quartz and the ferrodolomite (Uglow, 1922).

8. QUEEN BESS (92P-042)

The Queen Bess property, covering lead-zinc-silver vein mineralization in upper Fennell basalts, is located just east of the North Thompson River at the north end of Queen Bess Ridge, approximately 7 kilometres south of Blackpool. The property was first staked in 1895 (Iron Clad and Lone Prospector claims) and developed underground between 1917 and 1920 when it produced 73 tonnes yielding 52 222 grams of silver, 13 789 kilograms of lead and 12 503 kilograms of zinc. Further production was attempted in 1927, but the mine was abandoned later the same year; this was apparently the last attempt to work the property.

The underground workings at the Queen Bess property are described by Uglow (1922), Walker (1930) and McCammon (Minister of Mines Annual Report, 1951, pages 125-128). They report that most of the mineralization occurs in two veins which range from 30 centimetres to more than 1 metre in width. The Cameron vein strikes northeast and dips 50 to 75 degrees northwest, while the Bigelow vein, intersected 50 metres farther east in the main adit crosscut, strikes 20 to 30 degrees and dips vertically to very steeply west. The veins are continuous and generally well defined throughout the workings, but good mineralization, comprising massive pods and lenses of sphalerite and galena, is erratically and often sparsely distributed through them. Poorly mineralized sections consist of quartz and rusty carbonate, with or without disseminated sulphides. Tetrahedrite and pyrite reportedly occur in minor quantities with the sphalerite and galena.

Country rock in the vicinity of the Queen Bess property is typical upper Fennell basalt, in places with good pillow structures preserved. The basalts are cut by a number of steeply dipping northeast to east-striking shear(?) zones containing rusty carbonate and quartz, which typically display rusty carbonate alteration envelopes.

9. CC (CHU CHUA) (92P-140)

The Chu Chua massive cupriferous pyrite deposit occurs within upper Fennell basalts a short distance east of Chu Chua Mountain, about 22 kilometres north-northeast of Barriere. Interest in the area was first aroused in 1977 when Vestor Explorations Ltd. discovered a large gossan with a strong copper anomaly in soils approximately 1 kilometre downslope from the deposit. The gossan was interpreted to be transported and prospecting upslope led to discovery of a much smaller gossan, with slightly anomalous copper values, adjacent to a northerly trending magnetite body. Massive sulphides were discovered in 1978 by Craigmont Mines Limited when they optioned the property and drilled the small gossan. Further drilling in 1978 and 1979 outlined reserves of approximately 2 million tonnes grading 2 per cent copper, 0.4 per cent zinc and 0.1 per cent cobalt. The following is a brief summary based on interpretation from drill core logged by McMillan (1980) of this Ministry and on a paper by Vollo (1981) of Craigmont Mines Limited.

The Chu Chua deposit consists of two major and several minor stratiform massive sulphide lenses associated with pyritic cherty rock and lenses of magnetite and magnetite-talc (Figure 16). Locally, a lens of massive fine-grained talc underlies one of the main sulphide bodies. The mineralized zone strikes north, dips vertically to steeply west, and is enclosed within pillowed and massive basalts of the upper Fennell Formation. The basalts directly east of the mineralized zone are hydrothermally altered to assemblages of mainly talc, carbonate and chlorite, and are locally bleached, silicified and sparsely mineralized; those on the west side are unaltered. This suggests that the deposit is proximal and faces west; this facing direction is consistent with top indicators (usually pillows) throughout the Fennell belt.

The massive sulphide lenses consist of pyrite with several per cent chalcopyrite and minor amounts of sphalerite. The associated magnetite lenses typically contain some pyrite and chalcopyrite but, except near the contacts with massive sulphide bodies, copper grades are usually low. The pyritic cherty rocks which are closely associated with the massive sulphides are generally massive and often brecciated; locally they are finely laminated. These may be chemical precipitates of volcanic exhalative origin. They appear to persist down dip

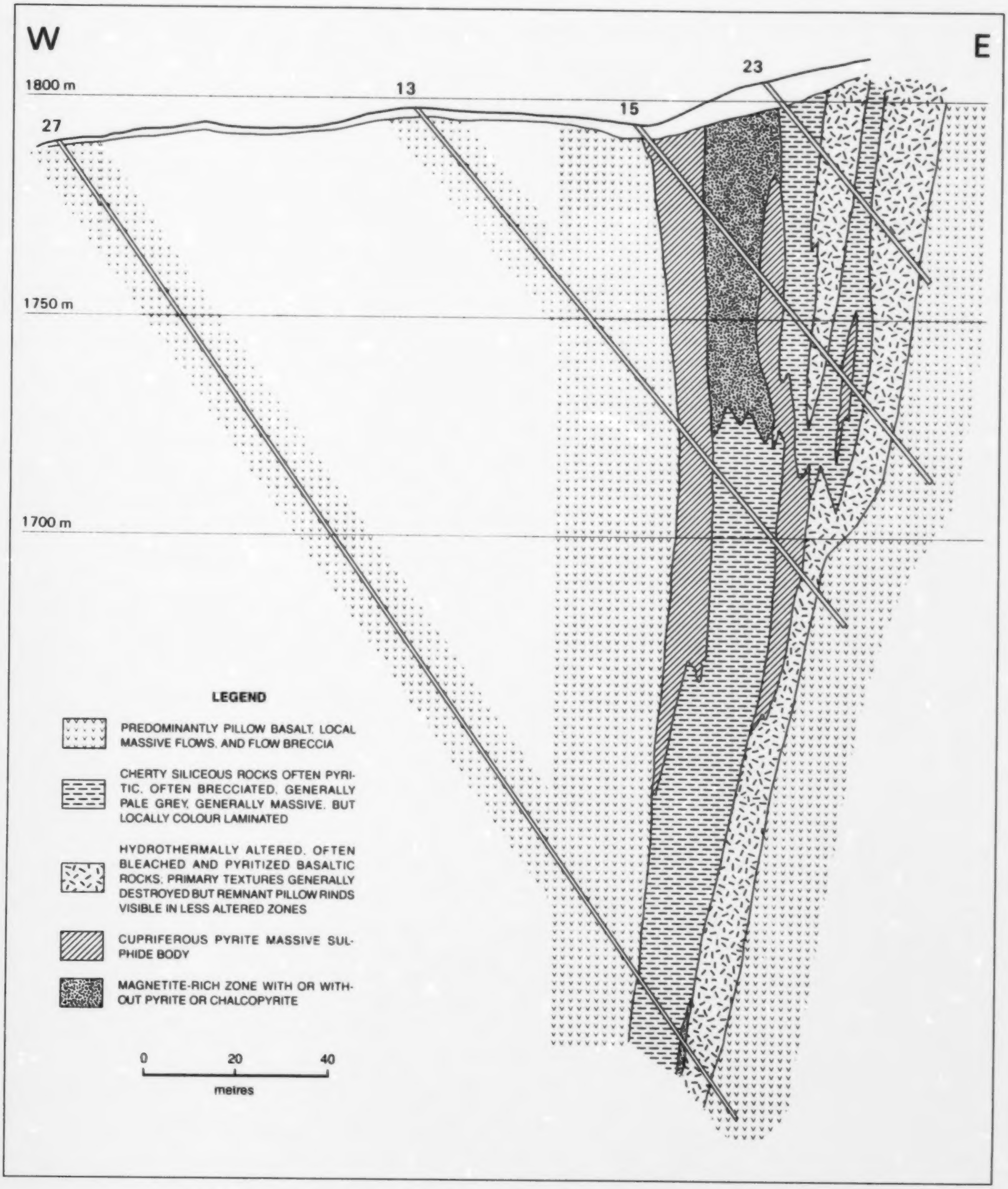
W
E
1800 m
1750 m
1700 m
27
13
15
23
LEGEND
PREDOMINANTLY PILLOW BASALT, LOCAL MASSIVE FLOWS, AND FLOW BRECCIA
CHERTY SILICEOUS ROCKS OFTEN PYRITIC, OFTEN BRECCIATED, GENERALLY PALE GREY, GENERALLY MASSIVE, BUT LOCALLY COLOUR LAMINATED
HYDROTHERMALLY ALTERED, OFTEN BLEACHED AND PYRITIZED BASALTIC ROCKS; PRIMARY TEXTURES GENERALLY DESTROYED BUT REMNANT PILLOW RINDS VISIBLE IN LESS ALTERED ZONES
CUPRIFEROUS PYRITE MASSIVE SULPHIDE BODY
MAGNETITE-RICH ZONE WITH OR WITHOUT PYRITE OR CHALCOPYRITE
0
20
40
metres

Figure 16. Cross-section through Chu Chua massive sulphide deposit, after McMillan (1980).

and along strike from the massive sulphides and may, in part, be distal equivalents of the proximal sulphides. The areas of talc deposition are interpreted by Aggarwal and Nesbitt (1984) to represent the exhalative vents of the mineralizing solutions.

10. ENARGITE (82M-065)

The Enargite (Energite, North Star) showings consist of sulphide-bearing quartz veins which cut sheared rocks along the faulted Fennell/Unit EBP contact. The main showings are located on the southwest slopes of upper Birk Creek at an elevation of approximately 1600 metres; similar mineralization is reported along the banks of Birk Creek 1200 metres to the northwest. The area has been staked and explored intermittently since the early 1920s. It is presently owned by Kam Creed Mines Ltd.

At the main showings, mineralization is exposed in a series of trenches, stripped areas and short adits along a northerly trending zone several hundred metres long by several tens of metres wide. It comprises a system of quartz veins and disconnected lenses containing pods of coarse-grained galena and pyrite with lesser sphalerite and chalcopyrite. Individual veins and lenses generally range from a few centimetres to 1 metre in width; they are variable in thickness and orientation, although northerly strikes and moderate (40 to 50 degrees) easterly dips predominate. Four and a half tonnes of ore shipped to Cominco Ltd. in September of 1972 contained 39.8 grams per tonne gold, 707.9 grams per tonne silver, 27.4 per cent lead, 13.3 per cent zinc and 0.25 per cent copper (George Cross Newsletter, January 5, 1983).

The steeply dipping host rocks, which in places display rusty carbonate alteration, range from Fennell Formation bedded chert in the west, through sheared and brecciated phyllite, to less sheared phyllite, sandstone and grit of Unit EBP, in the east. Mississippian limestone of Unit EBPl outcrops a short distance southeast of the showings, but is not known to be mineralized.

11, 12. FORTUNA 1 (82M-072), FORTUNA 2 (82M-070)

The Fortuna 1 and 2 showings are located on the slopes east of Birk Creek, 1 to 2 kilometres south of the Baldy batholith. They were discovered in the early 1920s and subsequently explored by a series of opencuts and at least one short adit. They have apparently received little recent attention. The showings comprise a series of steeply dipping, generally northerly striking quartz veins which contain pods of coarse-grained galena. Pyrite, chalcopyrite and sphalerite are locally present in minor quantities. At Fortuna 1, the veins cut flat-lying sericite quartz phyllites of Unit EBA; the host rock at Fortuna 2 is mainly brownish grey siltstone that is assigned to Unit EBQ.

13-18. COPPER CLIFF (82M-067), RAINBOW (82M-067), C-C (82M-067), MAY (82M-131), BROKEN RIDGE (82M-130), HARPER (82M-060)

These showings are mainly stratiform lenses of massive to disseminated sulphides within Unit EBA where it is exposed between the Barriere River fault and the Baldy batholith in the vicinity of Birk and Harper creeks. Mineralization was discovered in about 1920 and most of the showings had been explored by hand tunnelling and trenching prior to 1930. In 1938 and 1940 a total of 234 tonnes of ore shipped from lower Birk Creek yielded 6501 grams of gold, 13 499 grams of silver and 4800 kilograms of copper. Between 1950 and the late 1970s exploration activity has included geological and geochemical surveys, trenching and diamond drilling carried out by Northwestern Exploration Ltd., Mining Corporation of Canada Ltd., Ducanex Resources Limited, Kennco Explorations (Western) Limited, and Cominco Ltd.

The Copper Cliff, Rainbow and C-C showings occur along the lower reaches of Birk Creek. Together with the Lynx showing 400 metres north of the creek, they have over the years been variously included within the Anaconda, Lynx, OK, and Iron Cap claim groups as referred to in old assessment reports and annual reports of the Minister of Mines. The showings are marked by about a dozen old adits and trenches; most cannot be unequivocally assigned to a specific showing name. The host rock is mainly flat lying, light silvery grey chlorite-sericite-quartz schist of felsic volcanic origin. The schist is commonly pyritic, often contains prominent "eyes" of quartz and feldspar, and is locally fragmental. Lesser amounts of dark grey phyllite and siltstone, together with minor amounts of limestone, are intercalated with the schists.

At the C-C showing, a band of semimassive pyrite-galena-sphalerite-chalcopyrite mineralization, 10 to 20 centimetres wide, occurs within a 1 to 2-metre band of siliceous pyritic schist that is enclosed within typical silvery schists. The several adits farther upstream (Rainbow and Copper Cliff showings) expose similar mineralization as well as stratiform bands of massive pyrite that are locally in excess of 3 metres thick. The pyrite is locally brecciated and, at one place, pyrite clasts occur within a siliceous fragmental schist structurally beneath a massive pyrite horizon. In many places the pyrite is barren, but locally it is associated with pyrrhotite, chalcopyrite, galena and sphalerite. The sulphide lenses occur within relatively siliceous zones enclosed within chlorite-sericite-quartz schists, although a massive pyrite lens exposed at the Lynx showing is hosted by dark grey phyllite. Stratigraphic relationships between the exposed mineralized horizons are generally not clear, although Goutier *et al.* (1985) indicate that there are at least two zones of massive sulphide mineralization exposed along the creek. Mesoscopic, east-trending, early recumbent folds within the area point to the possibility that larger scale structures may effect the distribution of the mineralized zones.

The May, Broken Ridge and Harper showings occur along Harper Creek, a short distance south of the Baldy batholith. Mineralization in these areas is in part similar to that along Birk Creek, but also includes disseminated to massive pyrite-pyrrhotite-chalcopyrite-magnetite mineralization within dark green actinolitic (calc-silicate) schists that are intercalated with sericite quartz schists typical of Unit EBA.

19. EBL (82M-051)

The EBL property, owned in 1983 by George Moore and James Gourlay of Vancouver, is located between the northeast ends of North and East Barriere lakes, a short distance southwest of the Baldy batholith. Extensive diamond drilling carried out by various companies between 1969 and 1974 indicates the presence of a large tonnage of low-grade (0.20 to 0.44 per cent) copper mineralization. There are few outcrops on the property. The numerous drill holes intersect a succession of generally biotitic chlorite schists, accompanied by fine to medium-grained schists comprised of varying proportions of quartz, feldspar, sericite, biotite and chlorite, and minor amounts of grey phyllite and limestone. These rocks are tentatively included in Unit EBQ. Quartzofeldspathic orthogneiss occurs in some drill holes, and a large mass of Devonian orthogneiss is inferred to occur at depth, based on projection of the EBQ/Dgn contact northward from the south side of East Barriere Lake (Figure 4). Pyrite, pyrrhotite and lesser chalcopyrite occur as light to heavy disseminations (in part concentrated along foliation planes), as fracture fillings, as thin stringers, and within quartz-carbonate veinlets. This type of mineralization occurs in a variety of lithologies but appears to be most abundant in chloritic schists. Pyrrhotite-pyrite-chalcopyrite-magnetite mineralization in garnet-epidote-chlorite-quartz skarn is also present, associated with amphibolite and limestone.

Mineralization on the EBL property is very similar to that at the Harper Creek deposit, located 20 kilometres to the north on the north side of the Baldy batholith. Both deposits occur within the third fault slice of the Eagle Bay Assemblage, but the EBL host rocks are tentatively assigned to Unit EBQ and thus inferred to be lower in the stratigraphic section than the Unit EBA rocks which host the Harper Creek mineralization (Figures 6 and 7). In each case, however, the mineralization occurs within rocks that are intruded and underlain by Devonian orthogneiss.

20. JUNE (KAJUN) (82M-058)

The June showing is 450 metres southeast of the East Barriere Lake shoreline, 4 kilometres east of the lake's outlet. It comprises sulphide-bearing quartz lenses within dark grey phyllite and siltstone, and within a siliceous lens in structurally overlying limestone. The host rock (EBGp) occurs in the upper part of Unit EBG. The showing has been known since at least 1960 and has been subjected to limited geological, geophysical and geochemical work, much of it by Western Mines Limited (now Westmin Resources Limited) in the early 1970s.

Outcrop at the June showing consists of a northerly trending limestone bluff, 15 to 20 metres high and about 100 metres long, that is underlain by dark grey phyllite and siltstone. The contact is a thrust (?) fault which dips 20 to 25 degrees to the east. The gently east-dipping grey laminated limestone above the fault contains a concordant lens of very fine-grained siliceous rock (silicified limestone ?) which is generally less than 1 metre thick, but thickens substantially where it passes through a recumbent fold pair exposed near the south end of the bluff. Mineralization occurs within the thickened siliceous zone in the fold hinges, and comprises mainly galena, sphalerite, chalcopyrite and pyrite in pods and lenses of quartz, calcite and dolomite. The phyllite and siltstone beneath the fault contain irregular lenses of vein quartz containing the same sulphide minerals. This mineralization appears to be most common adjacent to the fault.

21. TWIN MOUNTAIN (82M-020)

The Twin Mountain showing is located approximately 5 kilometres south of the west end of Johnson Lake. It consists of sulphide-bearing quartz-carbonate-barite lenses within a conformable zone of relatively pyritic and calcareous chlorite-sericite-quartz schists of Unit EBG. The area was first staked in 1936, and the mineralized zone was traced for almost 1400 metres through 12 trenches. Further work was carried out in the early 1950s when two exploration tunnels were driven, and also in the late 1960s when geochemical soil sampling outlined a zone anomalous in lead and zinc extending over 4.5 kilometres and coincident with the exposed mineralization. The ground was restaked in 1980 and purchased by Apex Energy Corporation in 1982. In 1983 Apex entered into an option agreement with Austin Resources Inc.; the two companies subsequently optioned the property to Corporation Falconbridge Copper (now Minnova Inc.).

The mineralization occurs within a conformable, northeast-dipping zone of grey pyritic and calcareous chlorite-sericite-quartz schists enclosed within darker green chlorite schists of Unit EBG. The zone is several metres to more than 10 metres wide and has been traced, through intermittent exposure with variable mineralization, for a strike length of more than 4 kilometres (Graf, 1981, Assessment Report 8942). Galena-sphalerite-pyrite-chalcopyrite mineralization occurs in carbonate-quartz-barite lenses which are concordant, or nearly so, to foliation in the enclosing schists. The carbonate is largely dolomite, but also includes calcite and siderite. The lenses range up to several metres in thickness, and locally display considerable pinch and swell. Mineralization within the lenses is erratic and ranges from sparse disseminations to massive pods of mainly galena and sphalerite up to 10 centimetres wide. Precious metal values are generally low, although a 1936 sample apparently yielded 17 grams per tonne gold across 60 centimetres (0.5 ounce per ton across 2 feet) (Minister of Mines Annual Report, 1936, page D39).

The presence of barite at the Twin Mountain showing is of particular interest; elsewhere in the map area it is known only in association with volcanogenic massive sulphides at Homestake and Rea. This, together with the extensive conformable strike length of the mineralized zone, has promoted recent speculation that the mineralization, previously referred to as a vein system, may be the product of an exhalative system associated with the volcanic rocks of Unit EBG. Comparison with Homestake and Rea is tenuous, however, since the Devono-Mississippian rocks which host these deposits are inferred to be separated by a thrust fault from overlying Unit EBG rocks, which are at least in part of Early Cambrian age.

22. REA (82M-191)

The Rea massive sulphide showing is located on the slopes southeast of Johnson Creek, approximately 3.5 kilometres southwest of the west end of Johnson Lake (Plate 24). It was discovered in October 1983 by prospectors A. Hilton and R. Nicholl, both of Kamloops, optioned to Rea Gold Corporation, and in turn optioned to Corporation Falconbridge Copper (now Minnova Inc.). Drilling carried out by Corporation Falconbridge Copper in 1983 and 1984 indicated possible reserves of 136 080 tonnes grading 14.74 grams per tonne gold, 120 grams per tonne silver, 3.6 per cent zinc, 3.1 per cent lead, and 0.7 per cent copper, in two massive sulphide lenses (Northern Miner, March 7, 1985). Additional reserves reportedly occur in another massive sulphide lens discovered by Falconbridge in 1985 (T. Höy, personal communication, January 1986). The following brief summary of the geology and mineralization is based on reports by White (1985) and Höy and Goutier (1986).

The Rea sulphides occur within an overturned panel of Unit EBF metavolcanic and metasedimentary rocks which dip at

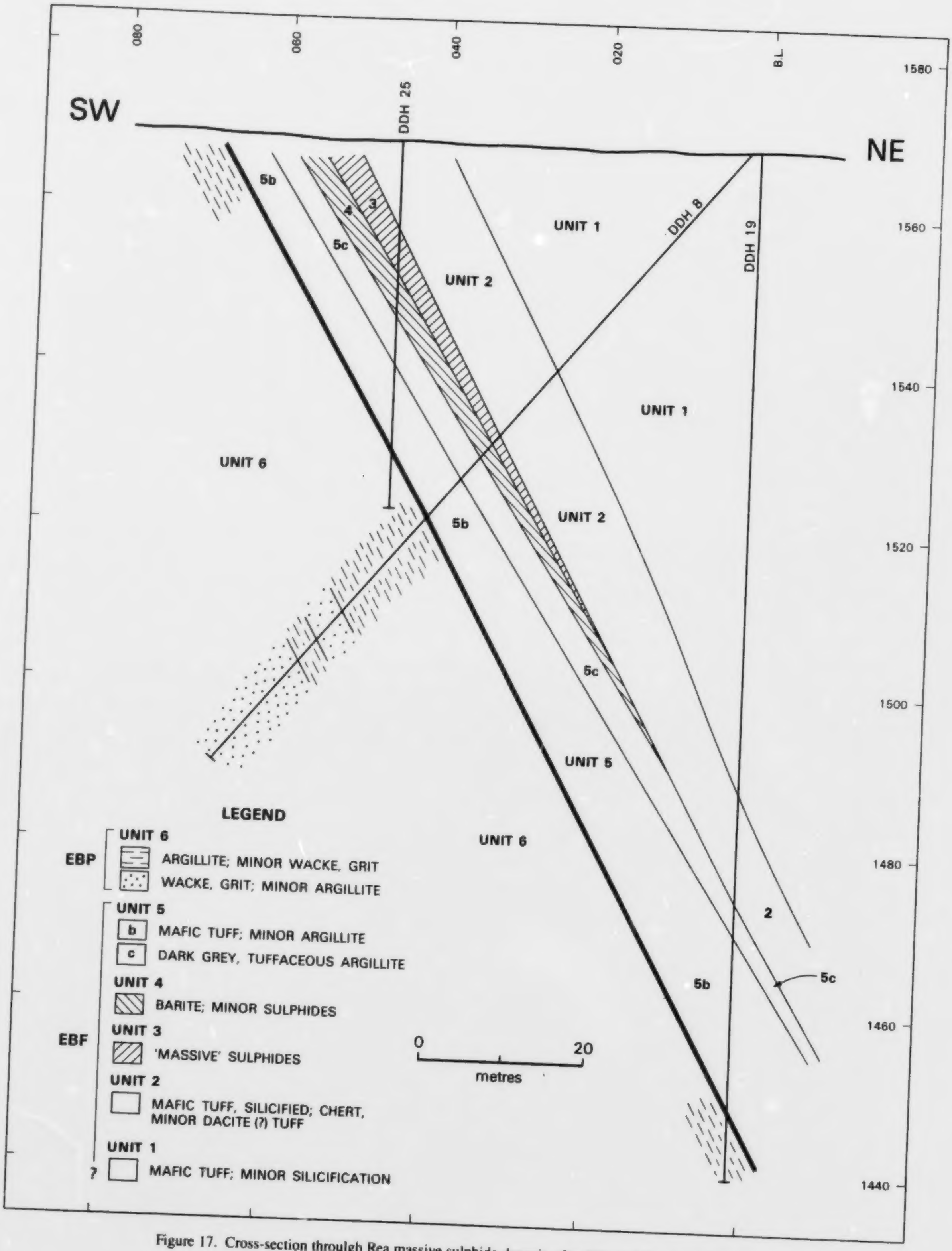

Figure 17. Cross-section throulgh Rea massive sulphide deposit, after Höy and Goutier (1986).

Plate 24. Trenches at the Rea (Hilton) gold-silver-lead-zinc-copper deposit. The view is south toward high mountains underlain by the Baldy batholith.

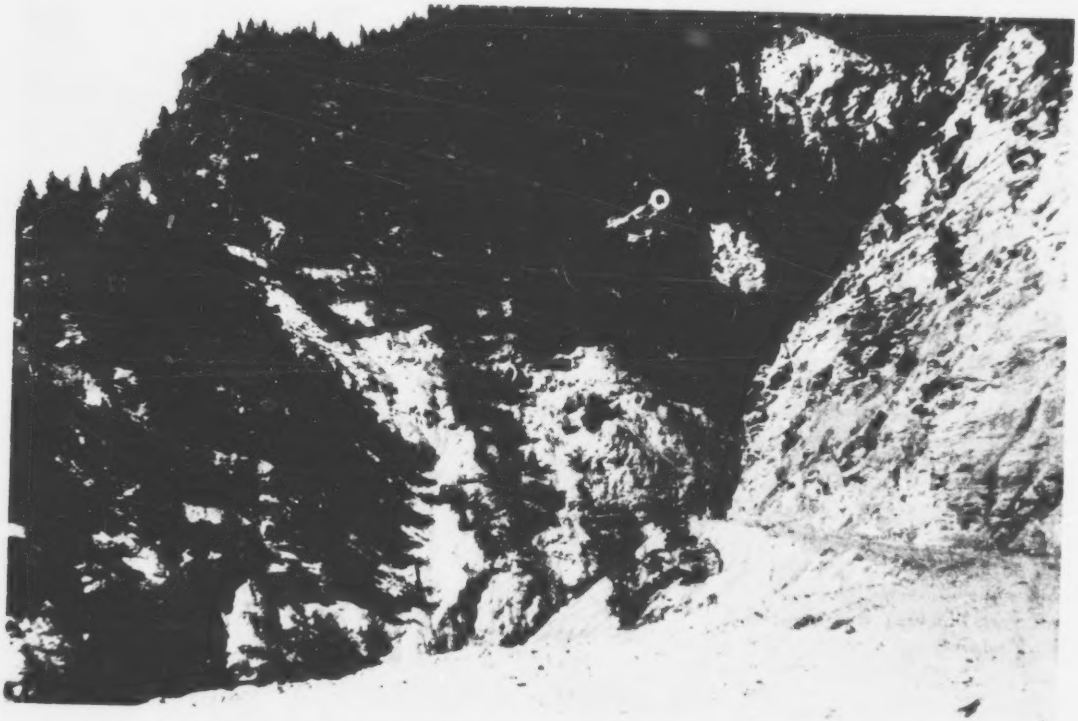

Plate 25. Bleached altered rocks around the Homestake deposit; the upper adit is left of the truck.

moderate angles to the northeast (Figure 17). The mineralization, as outlined in 1983 and 1984, occurs mainly in two massive sulphide lenses approximately 200 metres apart and at about the same stratigraphic level. Sulphide minerals include pyrite, sphalerite, galena, arsenopyrite, chalcopyrite and tetrahedrite-tennantite. According to White (1985), they "range from fine grained, massive with faint breccia texture, to medium grained and banded". The sulphides are structurally overlain by a thin felsic tuff and exhalative chert sequence, which is in turn structurally overlain by a thicker sequence of relatively mafic tuffs. These rocks display pyrite and sericite alteration, silicification, and local carbonatization and sodium enrichment, characteristic of footwall alteration and feeder zones. Locally the sulphides are structurally underlain by massive barite and by mafic tuffs which grade downwards into a sequence of argillites, siltstones and coarse wackes. Crossbedding and graded bedding in the metasedimentary rocks indicate that the succession is overturned, as does the spatial relationship of "footwall alteration" and barite to the massive sulphides.

The overturned fragmental metavolcanics and metasediments at the Rea showing belong to Unit EBF of this report, while mafic metavolcanic rocks exposed several hundred metres northeast of the showing are assigned to Unit EBG. White (1985) suggests that this entire sequence is inverted, that Unit EBG sits stratigraphically beneath Unit EBF, and that the massive sulphides occur at the top of Unit EBG (*see* Figure 19 of White, 1985). According to the present interpretation, Unit EBG is in thrust contact with underlying rocks of Unit EBF and the Rea deposit occurs within overturned Unit EBF rocks beneath this thrust. This interpretation requires that the mafic pyroclastic rocks mapped by White northeast of the sulphide lenses consist of two different sequences, an overturned interval of Unit EBF rocks and, farther northeast, the mafic metavolcanic rocks and limestone (presumably right-way-up) of Unit EBG. The (thrust) contact that separates the two units presumably occurs at, or northeast of, the zone of strongly altered rocks which comprises the stratigraphic footwall of the Rea mineralized zone.

23. HOMESTAKE (82M-025)

Homestake is a polymetallic base and precious metal/barite deposit within Unit EBA. It occurs on the north side of Sinmax Creek, approximately 5 kilometres northwest of Squaam Bay (Plate 25). The mineralization was discovered in 1893 and underwent some development, including the shipment of about 18 tonnes of high-grade ore, between then and 1895, when activity ceased for a period of more than 20 years. Subsequent work has been sporadic but included the production of 6962 tonnes of ore between 1926 and 1941 which yielded 11 259 grams of gold, 8751 kilograms of silver, 9138 kilograms of copper, 141 295 kilograms of lead and 203 310 kilograms of zinc. Much of the production occurred in 1935 and 1936 when a 30 to 40-ton-per-day flotation mill was operating on the property. The mine was acquired by its present owner, Kamad Silver Co. Ltd., in 1968. Reserve estimates vary, but range up to about 1 000 000 tonnes grading 200 grams per tonne silver, 2.5 per cent lead, 4.0 per cent zinc, 0.5 per cent copper and 28 per cent barite. The deposit is presently under reassessment and 40 tonnes of ore were shipped in 1983.

The Homestake deposit occurs near the top of a bleached, rusty yellowish weathering zone of pyritic sericite quartz schist which can be traced within Unit EBA for most of the distance between Johnson Creek and Squaam Bay [*see* Höy and Goutier (1986) for a detailed description of the geology around the deposit]. The schistosity and compositional layering dip at shallow to moderate angles to the northeast, into the hillside. Mineralization, as described in Minister of Mines Annual Reports (1927, 1936), occurs mainly in two tabular horizons generally separated by 4 to 5 metres of schist. The lower horizon consists mainly of barite which contains thin sulphide laminae. It ranges from less than 1 metre to several metres in thickness, and generally comprises several barite bands separated by layers of schist. The upper horizon, usually less than 1 metre thick, contains most of the sulphides and silver mineralization; it is the source of the ore mined to date. It consists of alternating bands of metallic minerals, barite and quartz sericite schist, which are cut by veins and lenses of quartz. The metallic minerals include tetrahedrite, galena, sphalerite, pyrite, chalcopyrite, argentite, native silver and traces of ruby silver and native gold.

24, 25. BECA (82M-055), JOE (82M-054)

The Beca showings, located on the east side of Adams Lake southeast of Squaam Bay, and the Joe showings, approximately 2.5 kilometres farther south along the lakeshore, consist of conformable sulphide lenses within northerly dipping phyllite and schist of Unit EBA. The Beca showing has been known since at least 1926 (Minister of Mines Annual Report, 1926, page A186) when 5 tonnes of ore which yielded 31 grams of gold, 2395 grams of silver and 1498 kilograms of lead were reportedly shipped from the property. The showings received only modest intermittent attention from that time to the early 1970s, but were restaked by Cominco Ltd. in 1977, and subsequently acquired by Westmin Resources Limited which carried out 1100 metres of drilling on the Beca property in 1984.

The showings occur within a medium green, relatively chloritic phase of Unit EBA which locally contains lighter coloured siliceous clasts. The main mineralized zone consists of massive pods and lenses of sulphides within a conformable lens of rusty siliceous schist which is about 0.5 metre thick where exposed at the mouth of a caved adit. The sulphides include pyrite, galena, sphalerite, arsenopyrite and chalcopyrite; three samples from this lens yielded an average assay of 16.46 grams per tonne gold, 342.82 grams per tonne silver, 1.9 per cent lead, 1.3 per cent zinc and 0.8 per cent copper (Wojdak, 1977, Assessment Report 6680). A number of other narrow conformable lenses of siliceous pyritic rock occur for several hundred metres to the north and south of this mineralized zone; one of these, 100 metres to the north, contains galena, chalcopyrite and sphalerite, and yielded significant precious metal values.

The Joe showings occur within a thick band of greenish grey chlorite-sericite-quartz phyllite which commonly contains conspicuous "eyes" of quartz; thin horizons of dark green chloritic schist and dark grey phyllite and argillite are present locally. As is the case around the Beca showing, the phyllite contains a number of thin conformable lenses of rusty weathering siliceous pyritic rock. Two of these lenses,

Plate 26. Lucky Coon (north) lead-zinc-silver showing, Adams Plateau.

Plate 27. Exploration adit on the Spar (EX) lead-zinc-silver showing, Adams Plateau.

about 150 metres apart and marked by old adits, contain minor base metal mineralization as well as massive to heavily disseminated pyrite.

26-31. ELSIE (82M-012), LUCKY COON (82M-012), KING TUT (82M-013), SPAR (82M-017), PET (82M-143), MOSQUITO KING (82M-016)

These showings comprise stratabound sulphides of silver, lead and zinc which occur within the metasedimentary rocks of Unit EBGs in the core of the Nikwikwaia synform on Adams Plateau. Mineralization was discovered on the plateau in the early 1920s and some developmental work had been carried out by 1930. Little additional work was done prior to 1949, but the area has received considerable, although intermittent, attention from that time up to the present. Much of the work has been concentrated in the area around the Lucky Coon deposit (Plate 26), presently owned by Adams Exploration Ltd. (formerly Adams Silver Resources Inc.) and in the Mosquito King/Spar area (Plate 27), presently owned by Killick Gold Company Ltd. (formerly Orell Resources Ltd.). Numerous smaller showings occur on the plateau and new discoveries continue to be made. The deposits on the plateau have yielded the following modest production: from the Lucky Coon in 1975 and 1977, 920 tonnes yielding 713 grams of gold, 222 985 grams of silver, 131 738 kilograms of lead, 48 783 kilograms of zinc and 3822 kilograms of cadmium; from the Spar in 1952, 1953, 1955 and 1976, 455 tonnes yielding 435 grams of gold, 249 383 grams of silver, 77 967 kilograms of lead and 14 435 kilograms of zinc; from the Mosquito King in 1972, 1973 and 1979 (but possibily including some ore from the Spar), 566 tonnes yielding 218 grams of gold, 232 154 grams of silver, 22 755 kilograms of lead, 18 339 kilograms of zinc and 76 kilograms of cadmium.

The Adams Plateau showings occur within a dominantly metasedimentary succession (EBGs) of siliceous and/or graphitic phyllite, calcareous phyllite, streaky banded calc-silicate rock, limestone and quartzite. The succession dips at low to moderate angles northward within the core of Nikwikwaia synform. Although the stratigraphic facing direction is not definitely known, the fold is probably a syncline and showings north of the axial trace are therefore on its overturned limb. The metasediments are enclosed by chloritic schist and greenstone (Unit EBG) which lie stratigraphically beneath them, and are intruded by abundant dykes and sills of Late Cretaceous or Early Tertiary quartz feldspar porphyry, as well as by dykes of dark grey diabase.

Mineralization is generally hosted by siliceous to graphitic phyllite which may be intercalated with or dominated by argillaceous limestone and calc-silicate rock in the immediate vicinity of some showings (for example, Mosquito King). The mineralization comprises layers, lenses and pods of semimassive to massive sulphides, usually within a siliceous gangue. The dominant sulphides are pyrite, galena, sphalerite and chalcopyrite; pyrrhotite is common on the eastern part of the plateau while arsenopyrite, tetrahedrite and argentite occur in the Lucky Coon area. The sulphide horizons are locally well banded and conformable to the schistosity and, where observed, bedding in the host rock. A characteristic and perplexing feature of the sulphide horizons is their discontinuity and marked variability in width (from a few centimetres to as much as a few metres) along strike lengths which are in excess of several hundred metres in places. Much of this variation may be due to intense deformation. G. Dickie (in press) has noted that the sulphide horizons thicken in the hinge zones of both isoclinal, recumbent northeast to southwest-plunging synmetamorphic folds, and upright east-trending postmetamorphic folds. He suggests that exploration should be directed toward linear-plunging sulphide bodies localized and thickened in medium-scale fold hinges.

32. BC (82M-139)

The BC showings occur on the southeast corner of Adams Plateau, along the southeast boundary of the map area. They occur on the Bowler Creek claim block, owned by Killick Gold Company Ltd. The claims, which in part lie outside the map area, are underlain by siliceous phyllite and related metasediments of Unit EBGs, by chloritic and amphibolitic schists assigned to Unit EBG, and in the southeast by felsic schists of Unit EBA. The showings apparently include silver-lead-zinc mineralization in siliceous phyllites, as well as pyrite-pyrrhotite-magnetite-chalcopyrite mineralization in the chloritic schist and amphibolite assigned to Unit EBG (Black, 1974, Assessment Report 5132).

33. FORTUNA (92P-044)

The Fortuna showing consists of massive sulphide lenses within a pyritic sericite quartz phyllite horizon (EBSa) enclosed within grey phyllite and phyllitic sandstone of Unit EBS. It is located on the slopes north of Fraser Creek, 8 kilometres southeast of the settlement of Louis Creek; the mineralized horizon forms prominent rusty yellowish weathering bluffs a short distance above the Squaam Bay road. The northeast-dipping strata in this area are on the west limb of the Barriere anticline and are inferred to be overturned. Unit EBSa is lithologically very similar to much of Unit EBA and is likewise inferred to be of felsic volcanic origin. The Fortuna mineralization is not well exposed, but may comprise volcanogenic massive sulphides similar to that at Homestake and along lower Birk Creek.

The mineralization at Fortuna was first discovered near the turn of the century and three adits, one approximately 130 metres long, had been driven by 1908 (Minister of Mines Annual Report, 1908, page J123). Subsequent work has included some diamond drilling, but there are no records available as to when this took place. Mineralization found on an adit dump, and as float boulders on the slopes below the showing, consists of massive pyrite-pyrrhotite with traces of chalcopyrite. The main adit (now inaccessible) reportedly intersected three massive pyrite-pyrrhotite lenses, one almost 5 metres wide, conformable with the foliation in the host rock (Minister of Mines Annual Report, 1913, page 209). Only low base and precious metal values have been reported in the sulphides.

34-36. RED TOP (82M-044), SNOW (82M-045), SUNRISE (82M-046)

These showings occur near Mount McClennan, along the divide between the Raft and North Thompson rivers, 14 kilometres east of Clearwater. The Sunrise (Naomi) and Red

Top showings were staked prior to 1922 (Minister of Mines Annual Report, 1922, pages 145-146); the Snow showing, located between the other two, was staked a short time later. The showings received only sporadic attention prior to 1960. Since that time they have been explored by a number of companies, including Crowpat Minerals Ltd., Calbay Mining Corp. Ltd., Kerr, Dawson and Associates Ltd., Castlemaine Explorations Ltd. and Placer Development Limited. Exploration work included geochemical and geophysical surveys, the excavation of numerous trenches and adits, and drilling a number of short holes.

The Red Top, Snow and Sunrise showings occur within a heterogeneous succession consisting of quartzite, light to dark grey phyllite, limestone, calc-silicate schist and skarn. These rocks occur within the upper part of Unit EBQ, but are lithologically similar to, and may be correlative with, metasedimentary rocks of Unit EBGs (Figure 7). The mineralization is similar to that within Unit EBGs on the Adams Plateau.

The Red Top showing is 2 kilometres west of Mount McClennan. Four relatively recent trenches expose about 250 metres of moderately north-dipping metasediments. The succession consists mainly of platy quartzites, light green calc-silicate schists and light silvery grey phyllites, together with minor amounts of marble and dark grey phyllite and siltstone. A light grey marble band in the central part of the interval may correlate with a prominent marble unit exposed on the south face of Mount McClennan (Unit EBQl, Figure 4). The entire interval is rusty weathering and most lithologic units contain 1 to 3 per cent disseminated pyrite. Pyrite is most abundant in bands of light grey, yellowish rusty weathering pyrite-sericite-quartz schist that occur in at least three places in the succession; they range up to 2 metres in thickness. Base metal mineralization occurs mainly within a zone of very rusty platy quartzites 10 metres wide, just below the main marble band in the westernmost trench. Within this zone pyrite, galena, sphalerite and traces of chalcopyrite are present in quartz and quartz-carbonate lenses. Sulphide-bearing lenses are both concordant and discordant to the bedding and schistosity of the host rocks. Minor amounts of fine-grained galena and sphalerite (?) are locally disseminated in quartzites within and adjacent to this mineralized interval.

The Snow showing lies just south of Mount McClennan, 2 kilometres east of the Red Top showing. If the prominent marble on the south face of Mount McClennan correlates with the main marble band exposed in the Red Top trenches, then mineralization at the Snow showing is lower in the stratigraphic section than that at the Red Top (Figure 4). The showing is exposed by a series of old, largely caved, northerly trending trenches. Mineralization is hosted by a gently north-dipping succession of platy quartzites, quartz sericite schists, marble, calc-silicate schists and skarn. Most of the mineralization occurs in a 10 to 15-metre interval within which galena, sphalerite and traces of chalcopyrite are present as patches and disseminations in pyritic marble, calc-silicate schist and quartz sericite schist. The interval includes at least one pod of semimassive sulphides, about 20 centimetres thick, consisting mainly of pyrite and galena with traces of sphalerite and chalcopyrite.

The Sunrise showing is 1.3 kilometres east of the Snow showing and at about the same stratigraphic level. The mineralization is hosted by a flat-lying succession of platy quartzites, chlorite-sericite-quartz schists and chloritic schists that is overlain by marble, calc-silicate schist and quartzite. It is marked by a number of old pits and trenches, most of which are badly caved. Mineralization occurs mainly within two separate semimassive to massive sulphide zones, each about 1 metre thick, separated by several metres of platy quartzites and chlorite-sericite-quartz schists with local thin zones of rusty, pyrite-chlorite-quartz schist. The main sulphide zones consist predominantly of pyrite and pyrrhotite in chlorite-quartz-carbonate gangue; locally they contain sphalerite, galena and chalcopyrite. The mineralization has reportedly been traced over a strike length of more than 100 metres (Dawson, 1976, Assessment Report 5813).

37. SONJA (B.C., LEONIE) (82M-036)

The Sonja showings, which were first staked in the early 1900s as the B.C. claim (Minister of Mines Annual Report, 1913, pages 215-216), occur on the lower part of Crossing Creek, approximately 9 kilometres west of Vavenby. They were not examined by the writers but reportedly consist of a magnetite lens and quartz veins containing pyrite, galena, sphalerite and chalcopyrite, in silicified Eagle Bay rocks near a small granitic plug (Walker, 1931; Leitch, 1962, Assessment Report 436). The most recent work on the showings included trenching, stripping and clearing of old adits in 1978 and 1979 (Exploration in British Columbia, 1978, page E114; 1979, page 113).

38-40. BEARSDEN (82M-033), MORRISON (92M-047), TINKIRK (82M-032)

These showings lie on the slopes north of the North Thompson River, between 4 and 6 kilometres northwest of Vavenby. Mineralization was discovered early in the century and staked as the Bonnie Jean, Dreadnought and Last Chance claim groups (Minister of Mines Annual Reports, 1913, 1917, 1922, 1923). It has received little recent attention, although there was exploration on the Tinkirk and Bearsden showings in 1969 and 1970 (Geology, Exploration and Mining in British Columbia, 1969, page 228; 1970, page 296). Mineralization consists of quartz veins with local pyrite and galena. Two grab samples from the Morrison showing reportedly assayed 21 and 14 grams per tonne (0.6 and 0.4 ounce per ton) gold (Minister of Mines Annual Report, 1922, page N145; Leitch, 1962, Assessment Report 436).

41. CW (82M-159)

The CW showing is on the south side of the North Thompson River between Clearwater and Birch Island. Mineralization consists of pyrite and traces of chalcopyrite in a bleached silicified zone within metavolcanic quartz sericite schists of Unit EBA; locally the enclosing schists include medium to coarse-grained quartzofeldspathic gneiss of probable intrusive origin. The area was explored by Craigmont Mines Limited in 1977 and 1978, by Cominco Ltd. in 1979, and by its present owner, Newmont Exploration of Canada Limited in 1984 and 1985. The mineralized zone is best exposed in a railway cut directly opposite the mouth of the Raft River, and has been traced for almost 1500 metres to the southeast (Turner and Nebocat, 1985, Assessment Report

13559). Quartz veins carrying pyrite and galena occur along the same general trend 1900 metres to the northwest (*ibid*).

42. LYDIA (82M-008)

The Lydia showing lies on the west side of Foghorn Creek approximately 2.5 kilometres southeast of Foghorn Mountain. It comprises pyrite-pyrrhotite-chalcopyrite mineralization within chloritic phyllite, calcareous phyllite and quartzofeldspathic schist in the upper part of Unit EBQgn. The mineralization was discovered in the early 1900s and explored by two main adits, a number of short prospect adits, and several trenches prior to 1920. It received further attention in the early 1950s after uranium mineralization was discovered at Rexspar in 1949. The showing has been subjected to several geophysical, geochemical and diamond-drilling programs over the past 20 years; it is presently owned by MFC Mining Finance Corporation.

At the Lydia showing, pyrite, pyrrhotite and chalcopyrite are erratically distributed in quartz stringers, along fracture surfaces and as disseminations along foliation planes, across an interval of at least several tens of metres. Much of the mineralization, however, occurs within a more or less concordant zone, generally less than 2 metres thick, which has been traced for a strike length of about 350 metres (Dawson, 1979, Assessment Report 7758). Sulphides within this layer occur in disseminated to massive form, in layers and lenses aligned with the cleavage, in discordant quartz veins, and as steeply dipping, postcleavage fracture fillings.

The Shamrock showings, which are about 1 kilometre north of the Lydia, comprise several old adits that were driven along quartz veins containing variable amounts of pyrite.

43. HARPER CREEK (82M-007, 82M-009)

The Harper Creek prospect is a large, low-grade copper deposit located at the headwaters of Harper Creek, approximately 10 kilometres southwest of Vavenby (Plate 28). The western part of the deposit (Sue and Goof claims) was staked by Noranda Exploration Company Limited in April 1966 as a result of reconnaissance geochemical work. The eastern part (Hail claims) was staked by Quebec Cartier Mining Co. in June 1966. The two properties were explored independently until 1970, when a joint venture was formed with Noranda supervising the continued exploration and development. The exploration work included more than 22 000 metres of diamond drilling; geologically inferred reserves are 90 million tonnes grading 0.4 per cent copper. The deposit was studied by Belik (1973), and the brief summary that follows is taken largely from his work.

Mineralization occurs within Unit EBA, comprising a succession of light silvery grey quartz sericite phyllites intercalated with lesser amounts of green chloritic phyllite, dark grey carbonaceous phyllite and light grey sericitic quartzite. These rocks are locally intruded by minor amounts of quartzofeldspathic orthogneiss, which is also common in underlying rocks of Unit EBQgn. Mineralization consists mainly of pyrite with lesser amounts of chalcopyrite and pyrrhotite. Sphalerite, arsenopyrite, molybdenite, galena, tetrahedrite-tennantite, bornite and cubanite are present in very minor quantities. The sulphides occur as disseminations along schistosity surfaces; as bands of disseminated sulphides; as patches and disseminations within quartz and quartz-carbonate veins; and as thin coatings on steeply dipping, northerly striking fracture planes. Locally, the quartz

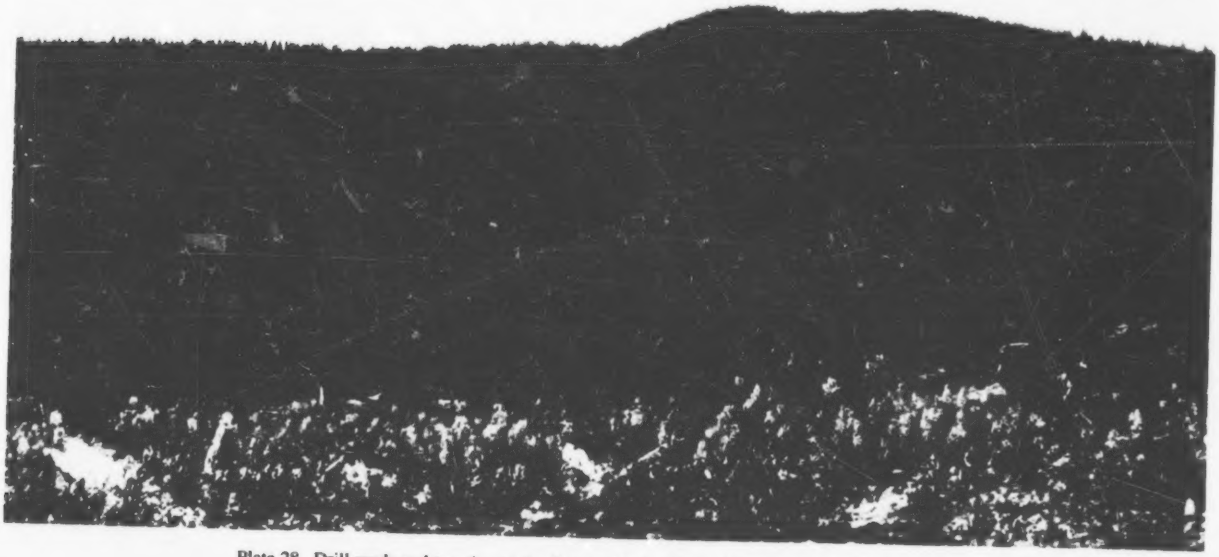

Plate 28. Drill roads and trenches at the Harper Creek copper deposit; view is to the northwest.

sericite phyllite contains lenses of massive pyrite-pyrrhotite with local concentrations of chalcopyrite; these lenses vary to several metres in thickness. Massive magnetite occurs locally within the sulphide lenses and also forms separate lenses containing minor amounts of chalcopyrite.

Copper mineralization occurs within tabular zones that dip to the north in approximate conformity with schistosity and lithological contacts of the host rocks. In detail, however, zones of copper mineralization transgress lithology and are not stratigraphically controlled (Belik, 1973). Most of the mineralization occurs within light silvery grey quartz sericite phyllite. The largest mineralized zone has a continuous strike-length of more than 1800 metres, a thickness that locally exceeds 100 metres, and persists down dip for at least 600 metres.

44. VM (82M-109)

The VM showings are located along a tributary of the Barriere River, 2 kilometres southwest of Avery Lake. The weakly disseminated copper mineralization was discovered in 1970, by Royal Canadian Ventures Ltd., during exploration for large tonnage, low-grade copper deposits similar to that at Harper Creek. Exploration by Cominco Ltd. in 1978 assessed the area's potential for volcanogenic polymetallic massive sulphide mineralization.

Mineralization is exposed in several old bulldozer trenches and along the bed of a small creek. It comprises pyrite and traces of chalcopyrite weakly and erratically disseminated along foliation and fracture planes within quartz-eye sericite schists and quartzofeldspathic schists and gneisses of Unit EBAgn. Grab samples typically assay 0.3 to 0.4 per cent copper with only traces of silver and gold (Naylor and White, 1971, Assessment Report 3525). Some of the host rocks are clearly of intrusive origin; more schistose varieties may be metavolcanic rocks but could be sheared intrusives.

45. VAV (ESP) (82M-151)

The VAV showings occur along a tributary of Reg Christie Creek, approximately 7 kilometres east of Vavenby. Disseminated copper mineralization was first discovered on the north side of Cedar Creek by Nicanex Mines Ltd. in 1969; similar mineralization was discovered south of the creek by Barrier Reef Resources Ltd. in 1976 and 1977. The mineralization consists of fine-grained pyrite, chalcopyrite and rare molybdenite, sparsely disseminated along foliation and fracture planes within sericite quartz phyllite and sericite-chlorite-quartz phyllite of Unit EBAgn. Locally the phyllite includes medium-grained quartzofeldspathic orthogneiss. Both the north and south showings are west-trending zones comprising mineralized outcrops and mineralized float extending over areas 800 to 1000 metres long by about 150 metres wide (Dawson, 1978, 1979, Assessment Reports 6933 and 7119). The mineralized zones include outcrops of barren rock and are separated by about 400 metres of apparently unmineralized rock. A limited amount of drilling was carried out by Nicanex Mines Ltd. in 1970 on the north zone, and by Barrier Reef Resources Ltd. in 1979 on the south zone; neither program encountered significant mineralization.

46, 47. HILLTOP (82M-114), HILLTOP 9 (82M-115)

The Hilltop showings occur at the headwaters of Gollen Creek, approximately 12 kilometres southeast of Vavenby. Copper mineralization was discovered by Dynasty Explorations Ltd. in 1971, which optioned ground staked by J.A. Fennell of Barriere to cover an area of mineralized float. Fennell restaked the area in 1975 and further work, including two X-ray drill holes totalling 76.5 metres, was carried out in 1976 and 1977.

Mineralization occurs mainly within chlorite schist and greenstone of Unit EBG, just east of its faulted contact with Cretaceous granitic rocks of the Baldy batholith. The chlorite schist in this area is variably silicified, pyritized and potassium-feldspathized (Brock and Roberts, 1971, Assessment Report 3430). Disseminated pyrite and chalcopyrite, with local lenses of pyrrhotite, occur in fractured and brecciated schist at several localities within this alteration zone.

The Hilltop 9 showing, located 2 kilometres east of the main zone of copper mineralization, comprises a pod of skarn within massive crystalline limestone of Unit EBGl. The skarn zone consists of epidote, diopside, calcite, chlorite and garnet with minor amounts of pyrrhotite, pyrite and chalcopyrite. It measures about 10 metres wide by 20 metres long and is apparently truncated by a northwest-trending fault at its eastern end (Brock and Roberts, 1971, Assessment Report 3430).

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Appendix 1.
Fossil Identifications

A. Conodont Identifications, by M.J. Orchard, Geological Survey of Canada, Vancouver.

Eagle Bay Assemblage

Field No. 'Enargite', GSC Loc. No. C-086307, Unit EBP; southwest side of Birk Creek, a short distance south of Enargite Pb-Zn showing; 51°20′52″N, 119°59′33″W.
Fauna: *Siphonodella copperi* Hass
Clydagnathus sp.
Polygnathus communis Branson & Mehl
Pseudopolygnathus sp.
Spathognathodus' sp.
Age: Early Mississippian.

Field No. 'Haggard 1', GSC Loc. No. C-087058, Unit EBP; 1.5 km south-southwest of the confluence of Haggard Creek and East Barriere River; 51°13′55″N, 119°56′27″W.
Fauna: *Cavusgnathus* sp.
Gnathodus girtyi Hass
G. texanus Roundy
G. bilineatus (Roundy)
Geniculatus sp.?
Age: Late Mississippian.

Field No. 'Haggard 2', GSC Loc. No. C-087093, Unit EBP; 700 m south-southwest of 'Haggard 1'; 51°13′34″N, 119°56′35″W.
Fauna: *Gnathodus girtyi* Hass
G. bilineatus (Roundy)
G. texanus Roundy
Rhachistognathus sp.
Age: Late Mississippian.

Field No. 'Haggard 3', GSC Loc. No. C-087092, Unit EBP; 50 m west of 'Haggard 2'; 51°13′34″N, 119°56′38″W.
Fauna: *Gnathodus girtyi* Hass
G. bilineatus (Roundy)
Paragnathodus commutatus (Branson & Mehl)
Rhachistognathus sp(p).
Hindeodus sp.
Kladognathus? sp.
Age: Late Mississippian.

The three 'Haggard' collections differ sufficiently to suggest a progressive younging from 1 to 3.

Fennell Formation

Field No. D68, GSC Loc. No. C-102408, Lower Fennell, third fault slice; head of Sprague Creek; 51°18′01″N, 120°00′48″W.
Fauna: *'Spathognathodus'?* sp.
Age: Devono-Mississippian?

Field No. M18, GSC Loc. No. C-102409, Lower Fennell; Garrison Mountain; 51°14′22″N, 120°03′02″W.
Fauna: *Neogondolella* sp.
Age: Permian.

Field No. MC4, GSC Loc. No. C-102412, Lower Fennell; 1.5 km south of Mt. Borthwick; 51°13′21″N, 120°04′12″W.
Fauna: *Neogondolella* sp.
Age: Permian.

Field No. MC7, GSC Loc. No. C-102413, Lower Fennell; 1 km west-southwest of Mt. Borthwick; 51°13′56″N, 120°04′55″W.
Fauna: *Gnathodus texanus* Roundy
Rhachistognathus? sp.
Age: Late Mississippian.

Field No. MC9, GSC Loc. No. C-102414, Lower Fennell; Barriere Lakes road, 3 km northeast of Barriere village; 51°12′28″N, 120°05′12″W.
Fauna: *Idiognathoides sinuatus* Harris & Hollingswith s.l.
Idiognathodus spp.
Neognathodus sp.
Gondolella cf. *G. laevis* Kosenko & Kozitskaya
Idioprioniodus sp.
Age: Middle(?) Pennsylvanian.

Field No. MC11, GSC Loc. No. C-102415, Upper Fennell; Leonie Creek, 3.5 km northeast of Genier Lakes; 51°14′34″N, 120°04′57″W.
Fauna: *Neogondolella serrata* (Clark & Ethington) group
Age: Middle Permian.

Field No. S9, GSC Loc. No. C-102416, Lower Fennell, first fault slice; southwest side of Birk Creek, 2 km south of Enargite Pb-Zn showing; 51°19′48″N, 119°59′12″W.
Fauna: *Neogondolella* sp.
Age: Permian.

Field No. S13, GSC Loc. No. C-102417, Lower Fennell, first fault slice; 4 km northwest of Sprague Creek/Barriere River confluence; 51°17′47″N, 119°58′33″W.
Fauna: *Neogondolella serrata* (Clark & Ethington) group
protoconodonts?
Age: Middle Permian.
The protoconodonts? are presumed reworked Cambro-Ordovician; their Colour Alteration Index is 7+ in contrast to CAI=5 for the Middle Permian conodonts.

Field No. S124, GSC Loc. No. C-102423, Lower Fennell, second fault slice; head of Chu Chua Creek, 1.2 km west of S9; 51°19′51″N, 120°00′13″W.
Fauna: *Gnathodus* cf. *G. bilineatus* (Roundy)
Idiognathodus sp.
Gondolella sp.
Age: Early(?) Pennsylvanian.

Field No. S140, GSC Loc. No. C-102431, Lower Fennell, first fault slice; south side of upper Birk Creek, 2.5 km north of S124; 51°21′14″N, 120°00′35″W.
Fauna: *Neogondolella* sp. indet.
Age: Permian.

Field No. V2, GSC Loc. No. C-102436, Lower Fennell, third fault slice; 1.7 km east of Chu Chua Mountain; 51°22′47″N, 120°02′55″W.
Fauna: *Neogondolella* sp. indet.
Age: Permian.

Field No. V83, GSC Loc. No. C-102439, Lower Fennell, first fault slice; 4.8 km east-southeast of Chu Chua Mountain; 51°22′13″N, 120°00′32″W.
Fauna: *Gondolella* cf. *G. laevis* Kosenko & Kozitskaya
G. cf. *G. magna* Stauffer & Plummer
Age: Middle(?) Pennsylvanian.

Field No. V90, GSC Loc. No. C-102440, Lower Fennell, first fault slice; southwest side of Birk Creek, a short distance west of the Enargite Pb-Zn showing; 51°20′57″N, 119°59′45″W.
Fauna: *Idiognathoides sinuatus* Harris & Hollingsworth s.l.
Idiognathodus sp.
Age: Early-Middle Pennsylvanian.

Field No. V90A, GSC Loc. No. C-102441, Lower Fennell, first fault slice; southwest side of Birk Creek, 200 m west of V90; 51°20′59″N, 119°59′52″W.
Fauna: *Neogondolella* sp.
Sweetognathus sp.
Age: Early Permian.

Field No. 7, PS81-1, GSC Loc. No. C-102442, Upper Fennell; 2 km north of Hallamore Lake; 51°31′15″N, 120°07′38″W.
Fauna: *Declinognathodus noduliferus* (Ellison & Graves)
Age: Early(?) Pennsylvanian.

Field No. PS81-50, GSC Loc. No. C-102458, Lower Fennell, first fault slice; west side of McDougal Creek, 4 km south of the North Thompson River; 51°36′02″N, 120°00′02″W.
Fauna: *Neogondolella serrata* (Clark & Ethington) gp?
Age: Middle(?) Permian.

Field No. PS81-66, GSC Loc. No. C-102461, Lower Fennell, fourth fault slice; 1 km west of McCarthy Mountain microwave station; 51°32′53″N, 120°04′20″W.
Fauna: *Gnathodus girtyi* Hass
G. cf. *G. bilineatus* (Roundy)
Age: Late Mississippian.

Field No. PS81-81, GSC Loc. No. C-102465, Lower Fennell, fourth fault slice; north side of Joseph Creek, 4 km east-northeast of Hallamore Lake; 51°31′02″N, 120°04′20″W.
Fauna: *Pseudopolygnathus* cf. *P. nudus* Pierce & Langenheim
Age: Early Mississippian.

Field No. PS81-108, GSC Loc. No. C-102468, Lower Fennell, third fault slice; Bottrel Creek, 1.5 km northwest of its confluence with the Barriere River; 51°15′02″N, 120°01′09″W.
Fauna: *Gnathodus girtyi* Hass
G. cf. G. bilineatus (Roundy)
Paragnathodus cf. *P. commutatus* (Branson and Mehl)
Age: Late Mississippian.

Field No. PS81-121, GSC Loc. No. C-102470, Lower Fennell, second fault slice; 4 km due south of Dutch Lake; 51°36′57″N, 120°03′13″W.
Fauna: *Idiognathoides sinuatus* Harris & Hollingsworth s.l.
Gondolella sp.
Age: Early-Middle Pennsylvanian.

Field No. PS81-123, GSC Loc. No. C-102472, Lower Fennell, third fault slice; 3.5 km east of Blackpool; 51°36′33″N, 120°03′48″W.
Fauna: *Gnathodus girtyi* Hass
Paragnathodus cf. *P. commutatus* (Branson and Mehl)
Age: Late Mississippian.

Field No. PS81-124, GSC Loc. No. C-102473, Lower Fennell, third fault slice; 2.7 km south of McCarthy Mountain microwave station; 51°31′35″N, 120°03′40″W.
Fauna: *Idiognathodus* spp.
Idiognathoides sinuatus Harris & Hollingsworth s.l.
Gondolella cf. *G. laevis* Kosenko & Kozitskaya
Age: Early-Middle Pennsylvanian.

Field No. PS81-135, GSC Loc. No. C-102478, Lower Fennell, second fault slice; north of Joseph Creek, 4 km southwest of Foghorn Mountain; 51°30′56″N, 120°00′04″W.
Fauna: *Neogondolella* sp. indet.
Age: Permian.

Field No. PS81-244, GSC Loc. No. C-102488, Lower Fennell, fourth fault slice; southeast of Joseph Creek, 3.5 km east of Hallamore Lake; 51°29′39″N, 120°04′44″W.
Fauna: *Neogondolella* sp.
Age: Permian.

B. Macrofossil Identification, by B. S. Norford, Institute of Sedimentary and Petroleum Geology, Calgary (Report No. 8-BSN-1985).

Field No. PS85-89, GSC Loc. No. C-103970, Tshinakin limestone member of Unit EBG; 4.5 km northwest of Vavenby, 51°36′28″N, 119°46′27″W.
Identifications: pelecypods(?)
minute loosely coiled organisms,
archaeocyathids, several genera
Age: Early Cambrian.

COMMENTS

The material is recrystallized but several genera of archaeocyathids can be differentiated. I am not personally familiar with this group of fossils and the collection is being forwarded to Dr. W. H. Fritz for further study. In Canada archaeocyathids are known only from Lower Cambrian rocks. In Siberia and in Australia, the group extends up into the lower Middle Cambrian, and there is a possible Upper Cambrian occurrence reported in Antarctica.

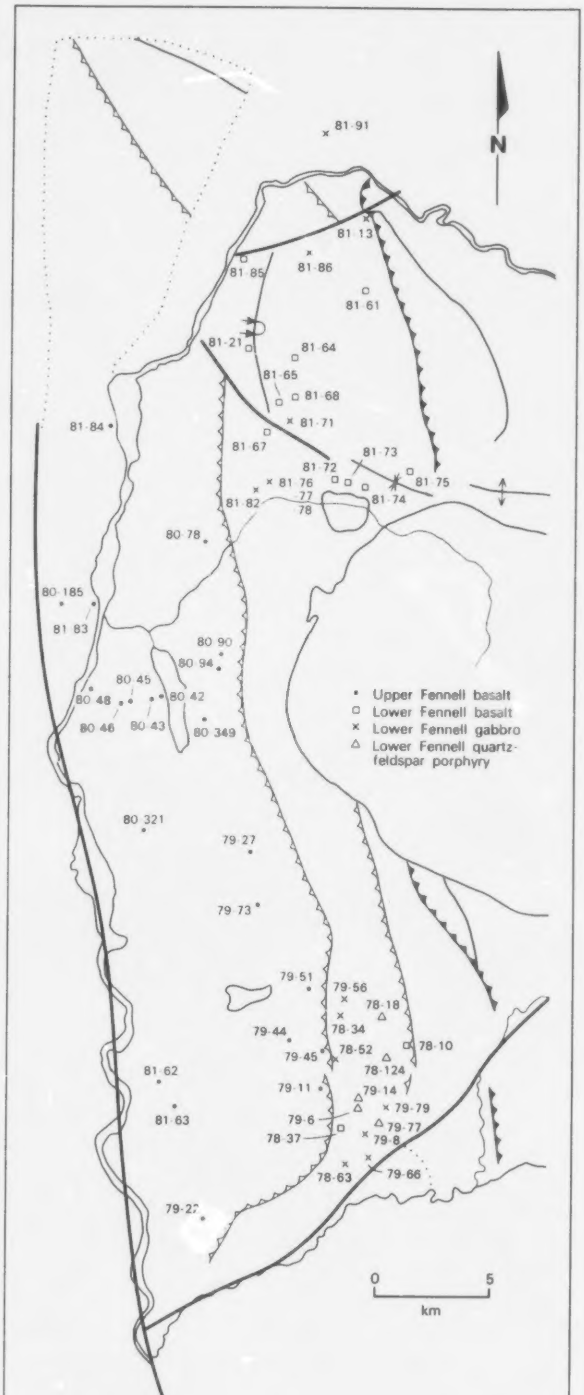

Figure 18. Sample localities for chemically analyzed Fennell Formation rocks listed in Appendix 2.

Appendix 2. Chemical Analyses and Molecular Norms of Fennell Rocks

	PS 79-11	PS 79-22	PS 79-27	PS 79-44	PS 79-45	PS 79-51	PS 79-73	PS 80-42	PS 80-43
	uFb	uFb	uFb	uFb	uFb	uFb	uFb	uFb	uFb
	%	%	%	%	%	%	%	%	%
SiO_2	49.62	48.05	48.92	51.31	49.45	49.34	51.10	47.37	50.09
TiO_2	1.91	1.56	1.75	1.51	1.51	1.83	1.56	1.75	1.53
Al_2O_3	15.46	17.53	14.45	14.55	15.34	15.42	15.31	15.40	15.78
Fe_2O_3	2.90	1.79	2.76	2.78	3.16	3.28	2.56	3.27	2.81
FeO	7.18	8.38	7.44	6.51	6.51	7.31	6.38	7.40	6.70
MnO	0.18	0.19	0.19	0.17	0.17	0.19	0.16	0.17	0.17
MgO	6.38	5.66	6.53	6.85	7.23	6.25	7.33	7.45	7.49
CaO	9.54	6.82	9.91	11.06	10.62	9.38	9.54	10.29	8.20
Na_2O	2.59	4.52	3.61	2.48	2.65	3.94	3.53	2.58	3.78
K_2O	0.29	0.27	0.13	0.21	0.46	0.09	0.35	0.14	0.29
P_2O_5	0.18	0.00	0.00	0.00	0.18	0.18	0.00	0.00	0.07
H_2O+	2.38	3.35	2.32	2.45	2.71	2.62	2.48	3.68	3.05
H_2O-	0.18	0.28	0.20	0.23	0.20	0.15	0.16	0.47	0.35
S	0.12	0.01	0.12	0.08	0.04	0.07	0.10	0.03	0.21
CO_2	0.10	0.10	0.22	0.42	0.10	0.17	0.31	0.37	0.37
Total	99.01	98.51	98.55	100.61	100.33	100.22	100.87	100.37	100.89
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	17	15	21	17	18	18	18	33	35
Cr	28	9	62	54	48	35	68	131	101
Cu	40	4	41	39	44	35	42	69	98
Mo	<3	<3	<3	<3	<3	<3	<3	2	<2
Ni	23	16	36	27	27	25	39	76	70
Pb	<3	4	5	4	4	4	3	6	161
Zn	55	40	56	42	47	59	46	101	86
V	318	230	318	230	230	200	187	315	210
Zr	90	78	75	77	86	68	63	90	80
Y	40	40	38	36	33	27	36	28	33
Sc	30	27	29	30	31	27	26	25	29
Li	7	7	<5	<5	<5	7	9	7	7
Nb	—	—	—	—	—	—	—	<6	<6
	%	%	%	%	%	%	%	%	%
Q	3.91	0.00	0.00	4.97	1.06	0.00	0.00	0.00	0.00
or	1.79	1.67	0.80	1.27	2.80	0.55	2.09	0.86	1.74
(ab)	24.35	42.43	33.82	22.87	24.50	36.28	32.05	24.17	34.47
(an)	31.10	27.97	23.84	28.71	29.45	24.75	25.18	31.33	25.63
pl	55.45	70.40	57.66	51.57	53.95	61.03	57.23	55.49	60.10
(wo)	6.89	2.96	10.99	9.97	9.17	8.27	8.28	7.80	5.14
(en)	5.03	1.82	7.84	7.52	7.06	5.97	6.39	5.83	3.96
(fs)	1.86	1.15	3.15	2.45	2.11	2.30	1.89	1.97	1.18
di	13.78	5.93	21.98	19.94	18.35	16.54	16.57	15.59	10.28
(en)	13.41	0.01	6.08	11.91	13.49	7.32	13.75	15.52	13.73
(fs)	4.96	0.00	2.45	3.89	4.04	2.83	4.08	5.25	4.11
hy	18.38	0.01	8.53	15.79	17.53	10.15	17.83	20.77	17.85
(fo)	0.00	10.89	3.67	0.00	0.00	3.31	0.25	0.09	2.49
(fa)	0.00	6.86	1.48	0.00	0.00	1.28	0.07	0.03	0.74
ol	0.00	17.74	5.15	0.00	0.00	4.59	0.32	0.11	3.23
mt	3.17	1.96	3.01	2.98	3.40	3.52	2.71	3.57	2.98
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.79	2.27	2.54	2.16	2.17	2.61	2.20	2.54	2.16
ap	0.39	0.00	0.00	0.00	0.39	0.39	0.00	0.00	0.15
py	0.11	0.01	0.11	0.07	0.04	0.06	0.09	0.03	0.19
cc	0.00	0.00	0.00	1.09	0.26	0.44	0.79	0.98	0.95

	PS 80-45	PS 80-46	PS 80-48	PS 80-78	PS 80-90	PS 80-94	PS 80-185	PS 80-321	PS 80-349
	uFb	uFb	uFb	uFb	uFb	uFb	uFb	uFb	uFb
	%	%	%	%	%	%	%	%	%
SiO_2	50.60	52.36	49.92	49.23	52.33	48.20	50.06	50.05	49.34
TiO_2	1.50	1.57	1.66	1.68	1.93	1.77	1.44	1.72	1.86
Al_2O_3	14.77	14.42	14.87	14.53	14.40	14.76	15.40	14.73	14.60
Fe_2O_3	3.38	3.69	2.45	2.57	1.51	2.31	1.88	3.18	2.62
FeO	6.70	6.01	7.40	7.96	8.24	8.80	7.26	7.12	8.66
MnO	0.24	0.17	0.16	0.17	0.17	0.20	0.14	0.18	0.20
MgO	6.73	5.95	7.58	7.73	6.54	7.21	7.56	7.09	6.95
CaO	9.39	9.58	8.50	8.96	8.89	10.66	6.83	9.94	9.08
Na_2O	4.09	3.93	3.80	2.92	3.81	2.62	4.62	2.55	2.80
K_2O	0.16	0.54	0.11	0.79	0.10	0.08	0.03	0.26	0.59
P_2O_5	0.00	0.00	0.00	0.00	0.09	0.00	0.22	0.00	0.00
H_2O+	2.83	2.35	3.32	3.21	2.19	2.47	3.68	2.93	3.05
H_2O-	0.45	0.29	0.15	0.33	0.24	0.31	0.41	0.26	0.28
S	0.05	0.01	0.08	0.03	0.14	0.17	0.34	0.03	0.06
CO_2	0.33	0.24	0.29	0.29	0.40	0.40	0.92	0.26	0.33
Total	101.22	101.11	100.29	100.40	100.98	99.96	100.79	100.30	100.42
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	34	33	33	33	33	33	35	38	32
Cr	122	133	200	140	141	138	134	124	120
Cu	34	53	57	50	55	55	62	60	51
Mo	<2	<2	<2	<2	2	<2	<2	<2	2
Ni	99	70	78	75	70	61	69	85	59
Pb	7	7	7	8	8	7	8	8	8
Zn	93	95	87	88	94	102	76	86	105
V	210	240	255	255	290	315	240	255	370
Zr	70	77	66	70	77	94	54	87	100
Y	26	26	24	20	36	40	13	28	33
Sc	31	25	26	21	29	31	20	27	30
Li	5	2	13	9	15	9	18	7	10
Nb	<6	<6	<6	<6	<6	<6	<6	<6	<6
	%	%	%	%	%	%	%	%	%
Q	0.00	1.59	0.00	0.00	1.48	0.00	0.00	3.58	0.65
or	0.96	3.24	0.67	4.82	0.60	0.49	0.18	1.59	3.61
(ab)	37.32	35.85	34.98	27.06	34.65	24.33	42.03	23.75	26.06
(an)	21.82	20.43	23.78	24.99	22.18	29.25	21.48	29.02	26.46
pl	59.13	56.29	58.76	52.05	56.83	53.57	63.51	52.76	52.52
(wo)	9.36	10.53	7.03	7.60	7.74	9.13	2.20	8.17	7.23
(en)	7.01	8.15	5.17	5.45	5.15	6.17	1.62	6.10	4.89
(fs)	2.35	2.38	1.87	2.15	2.58	2.97	0.59	2.07	2.34
di	18.72	21.05	14.06	15.21	15.47	18.27	4.41	16.34	14.46
(en)	7.81	8.54	11.54	13.08	13.14	13.79	12.35	14.20	15.01
(fs)	2.61	2.50	4.17	5.16	6.58	6.63	4.47	4.82	7.20
hy	10.42	11.04	15.71	18.24	19.72	20.42	16.82	19.03	22.21
(fo)	3.05	0.00	3.56	2.62	0.00	0.47	5.39	0.00	0.00
(fa)	1.02	0.00	1.29	1.03	0.00	0.23	1.95	0.00	0.00
ol	4.07	0.00	4.85	3.65	0.00	0.70	7.34	0.00	0.00
mt	3.59	3.92	2.63	2.77	1.60	2.50	1.99	3.45	2.84
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.12	2.22	2.37	2.42	2.72	2.55	2.03	2.48	2.69
ap	0.00	0.00	0.00	0.00	0.19	0.00	0.47	0.00	0.00
py	0.04	0.01	0.07	0.03	0.12	0.15	0.30	0.03	0.05
cc	0.85	0.62	0.75	0.76	1.02	1.05	2.36	0.68	0.87

	PS 81-62 uFb	PS 81-63 uFb	PS 81-83 uFb	PS 81-84 uFb	PS 78-10 lFb	PS 78-37 lFb	PS 81-21 lFb	PS 81-64 lFb	PS 81-67 lFb
	%	%	%	%	%	%	%	%	%
SiO_2	50.67	49.94	50.05	49.82	51.25	52.32	51.93	50.35	46.69
TiO_2	1.44	1.48	1.58	1.50	1.51	1.68	1.89	1.63	1.68
Al_2O_3	15.28	14.50	15.60	15.48	15.17	16.13	16.55	14.94	16.05
Fe_2O_3	2.32	3.05	2.38	3.41	1.91	2.56	2.73	2.55	3.86
FeO	7.31	6.51	7.31	5.85	8.51	6.38	7.44	7.98	7.57
MnO	0.17	0.15	0.19	0.16	0.18	0.16	0.17	0.19	0.19
MgO	7.73	6.55	7.29	6.73	6.36	5.30	4.40	6.85	7.94
CaO	7.67	11.21	9.82	11.98	5.96	7.02	8.28	10.37	9.06
Na_2O	4.27	3.49	3.22	2.98	4.29	4.41	3.42	2.83	2.92
K_2O	0.19	0.02	0.22	0.11	0.18	0.14	0.05	0.16	0.04
P_2O_5	0.00	0.00	0.14	0.07	0.11	0.14	0.34	0.18	0.15
H_2O+	3.11	3.11	0.68	2.48	3.21	2.40	2.86	2.82	3.19
H_2O-	0.27	0.26	0.28	0.18	0.21	0.20	0.09	0.12	0.16
S	0.04	0.06	0.00	0.14	0.00	0.27	0.15	0.01	0.00
CO_2	0.07	0.07	0.10	0.10	0.18	0.25	0.20	0.10	0.07
Total	100.54	100.40	98.86	100.99	99.03	99.36	100.50	101.08	99.57
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	20	19	19	19	19	17	15	19	21
Cr	76	67	50	62	21	10	8	39	68
Cu	56	43	41	54	4	50	3	21	4
Mo	<3	<3	<3	<3	<3	<3	<3	<3	<3
Ni	47	39	36	37	19	20	12	32	47
Pb	3	4	<3	3	5	3	4	3	4
Zn	52	55	60	50	51	53	51	58	60
V	200	230	200	220	255	243	195	172	200
Zr	72	68	70	75	63	63	68	70	87
Y	30	32	30	32	28	28	28	35	36
Sc	25	25	25	26	27	22	17	22	26
Li	12	7	<5	<5	17	<5	15	15	23
Nb	—	—	—	—	—	—	—	—	—
	%	%	%	%	%	%	%	%	%
Q	0.00	0.00	0.00	0.74	0.00	2.65	6.46	1.53	0.00
or	1.14	0.12	1.33	0.66	1.11	0.85	0.31	0.97	0.25
(ab)	39.01	32.32	29.49	27.25	40.19	40.81	31.89	26.10	27.29
(an)	22.35	24.59	28.01	29.06	22.55	24.53	30.80	28.34	31.82
pl	61.37	56.91	57.50	56.31	62.74	65.34	62.69	54.44	59.10
(wo)	6.55	13.11	8.04	12.14	3.02	4.17	3.82	9.32	5.39
(en)	4.78	9.83	5.80	9.73	1.92	3.02	2.42	6.41	4.09
(fs)	1.77	3.28	2.24	2.41	1.10	1.14	1.40	2.91	1.30
di	13.10	26.22	16.08	24.28	6.05	8.34	7.64	18.64	10.79
(en)	6.92	7.06	12.83	9.19	15.95	12.06	10.19	13.02	12.70
(fs)	2.56	2.35	4.95	2.28	9.11	4.57	5.87	5.92	4.05
hy	9.48	9.42	17.77	11.47	25.06	16.62	16.06	18.93	16.76
(fo)	7.51	1.32	1.42	0.00	0.34	0.00	0.00	0.00	4.52
(fa)	2.78	0.44	0.55	0.00	0.19	0.00	0.00	0.00	1.44
ol	10.30	1.76	1.97	0.00	0.53	0.00	0.00	0.00	5.96
mt	2.47	3.29	2.54	3.63	2.08	2.76	2.96	2.74	4.20
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.04	2.13	2.24	2.13	2.19	2.41	2.73	2.33	2.44
ap	0.00	0.00	0.30	0.15	0.24	0.30	0.74	0.39	0.33
py	0.04	0.05	0.00	0.12	0.00	0.24	0.14	0.01	0.00
cc	0.00	0.00	0.26	0.26	0.00	0.00	0.00	0.00	0.18

	PS 81-68	PS 81-72	PS 81-61	PS 81-65	PS 81-73	PS 81-74	PS 81-75	PS 81-85	PS 81-76
	IFb	IFb	IFb	IFb	IFb	IFb	IFb	IFb	IFg
	%	%	%	%	%	%	%	%	%
SiO_2	51.32	50.52	51.59	48.81	49.65	49.23	48.38	50.09	47.84
TiO_2	1.43	1.57	1.54	1.75	1.62	1.56	1.39	1.50	1.57
Al_2O_3	13.83	16.20	13.69	15.23	15.46	14.90	15.46	13.50	13.83
Fe_2O_3	2.40	2.94	4.14	3.16	2.25	4.05	3.80	2.14	4.21
FeO	7.31	7.31	5.85	7.31	8.24	6.38	5.85	8.24	6.51
MnO	0.18	0.16	0.16	0.18	0.19	0.17	0.16	0.19	0.19
MgO	7.09	7.09	5.90	7.07	8.06	7.25	6.88	8.58	8.55
CaO	9.99	10.15	10.14	10.57	10.02	10.91	10.96	10.38	10.26
Na_2O	2.94	3.46	4.02	2.91	2.85	1.97	2.89	2.62	2.64
K_2O	0.08	0.07	0.09	0.06	0.14	0.08	0.05	0.23	0.09
P_2O_5	0.07	0.07	0.28	0.14	0.07	0.23	0.39	0.14	0.07
H_2O+	2.40	2.06	2.10	2.83	1.52	1.58	2.82	0.76	3.01
H_2O-	0.09	0.04	0.07	0.34	0.09	0.08	0.11	0.12	0.19
S	0.08	0.14	0.00	0.02	0.05	0.03	0.00	0.00	0.00
CO_2	0.10	0.14	1.21	0.21	0.10	0.17	0.69	0.10	0.21
Total	99.31	101.92	100.78	100.59	100.31	98.59	99.83	98.59	99.17
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	21	21	19	21	22	21	19	24	22
Cr	54	70	47	49	63	61	65	90	80
Cu	46	50	55	6	33	47	44	8	8
Mo	<3	<3	<3	<3	<3	<3	<3	<3	<3
Ni	46	46	38	38	49	48	38	61	60
Pb	4	<3	6	3	5	4	8	<3	<3
Zn	63	60	52	52	68	64	60	72	60
V	180	155	187	195	230	200	180	242	180
Zr	65	50	72	70	70	66	56	75	60
Y	32	24	29	36	28	28	22	32	28
Sc	23	24	25	25	29	29	30	31	29
Li	12	23	9	14	13	14	11	12	12
Nb	—	—	—	—	—	—	—	—	—
	%	%	%	%	%	%	%	%	%
Q	3.28	0.00	2.07	0.40	0.00	5.76	1.96	0.01	0.40
or	0.49	0.41	0.55	0.37	0.84	0.49	0.31	1.39	0.56
(ab)	27.36	31.06	37.18	26.93	25.92	18.47	26.82	24.11	24.75
(an)	25.19	28.46	19.62	29.19	29.36	32.98	30.04	25.01	26.75
pl	52.55	59.51	56.79	56.13	55.28	51.45	56.86	49.13	51.50
(wo)	10.02	8.22	12.13	9.02	7.96	8.34	7.61	10.48	9.81
(en)	7.16	6.03	9.60	6.66	5.64	6.65	6.09	7.48	8.02
(fs)	2.86	2.19	2.52	2.36	2.32	1.69	1.52	3.00	1.79
di	20.04	16.43	24.25	18.04	15.92	16.69	15.21	20.96	19.63
(en)	13.12	10.81	7.18	13.46	13.78	14.26	13.54	16.80	16.62
(fs)	5.23	3.92	1.89	4.78	5.67	3.63	3.37	6.72	3.71
hy	18.35	14.72	9.06	18.24	19.44	17.89	16.91	23.52	20.33
(fo)	0.00	2.05	0.00	0.00	2.34	0.00	0.00	0.00	0.00
(fa)	0.00	0.74	0.00	0.00	0.96	0.00	0.00	0.00	0.00
ol	0.00	2.79	0.00	0.00	3.31	0.00	0.00	0.00	0.00
mt	2.60	3.07	4.46	3.41	2.38	4.42	4.11	2.29	4.60
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.06	2.19	2.21	2.51	2.29	2.27	2.00	2.14	2.28
ap	0.15	0.15	0.60	0.30	0.15	0.50	0.84	0.30	0.15
py	0.07	0.12	0.00	0.02	0.04	0.03	0.00	0.00	0.00
cc	0.26	0.35	0.00	0.55	0.26	0.45	1.80	0.26	0.55

	PS 81-77	PS 81-78	PS 78-34	PS 78-52	PS 79-56	PS 78-63	PS 79-8	PS 79-66	PS 79-79
	IFg	IFg	IFg	IFg	IFg	IFg	IFg	IFg	IFg
	%	%	%	%	%	%	%	%	%
SiO_2	51.07	50.93	51.32	51.59	48.06	47.97	47.28	50.62	51.94
TiO_2	1.66	0.60	1.34	2.22	0.81	2.75	1.17	1.16	2.34
Al_2O_3	14.99	15.86	15.64	15.63	13.38	15.73	10.82	18.18	15.65
Fe_2O_3	2.24	0.73	2.31	5.67	1.83	2.59	1.73	3.49	3.05
FeO	7.71	6.38	5.45	7.71	5.45	8.91	9.04	4.93	8.77
MnO	0.18	0.14	0.13	0.35	0.14	0.18	0.18	0.15	0.23
MgO	7.12	8.40	6.81	2.10	10.99	5.75	12.73	4.53	3.59
CaO	6.90	10.09	10.86	5.15	15.51	8.73	7.86	10.98	5.74
Na_2O	4.51	2.76	2.66	5.55	1.45	3.24	2.71	3.43	4.11
K_2O	0.10	0.96	0.05	0.30	0.02	0.74	0.25	0.28	0.04
P_2O_5	0.07	0.07	0.00	1.00	0.00	0.00	0.00	0.37	0.43
H_2O+	2.21	2.73	2.00	1.51	2.50	2.89	3.35	2.64	3.47
H_2O-	0.23	0.13	0.01	0.34	0.20	0.33	0.25	0.13	0.18
S	0.03	0.01	0.01	0.02	0.01	0.01	0.02	0.10	0.01
CO_2	0.35	0.79	0.18	0.00	0.07	0.21	1.86	0.10	0.99
Total	99.37	100.58	98.77	99.14	100.42	100.03	99.25	101.09	100.54
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	21	19	15	8	19	18	28	14	12
Cr	60	120	8	4	103	10	163	7	4
Cu	51	29	7	6	15	12	7	29	10
Mo	<3	<3	<3	<3	<3	<3	<3	<3	<3
Ni	45	57	15	<2	76	16	104	4	<2
Pb	6	4	3	3	3	3	5	3	4
Zn	70	35	18	51	10	24	45	38	73
V	187	150	275	57	195	450	275	147	140
Zr	58	15	60	112	48	80	62	27	131
Y	20	5	35	64	17	44	28	20	52
Sc	23	28	35	21	45	30	43	24	16
Li	12	12	<5	<5	<5	11	14	15	25
Nb	—	—	—	—	—	—	—	—	—
	%	%	%	%	%	%	%	%	%
Q	0.00	0.00	4.30	4.22	0.00	0.00	0.00	2.42	9.24
or	0.60	5.71	0.31	1.85	0.12	4.57	1.55	1.69	0.25
(ab)	41.35	24.97	24.75	52.05	13.21	30.41	25.52	31.38	38.60
(an)	20.79	28.27	31.70	17.60	30.37	27.38	17.44	34.02	20.30
pl	62.14	53.25	56.45	69.65	43.58	57.79	42.96	65.40	58.90
(wo)	4.57	6.67	9.65	0.91	18.89	7.16	9.39	7.35	0.00
(en)	3.22	4.85	7.58	0.47	15.67	4.67	7.09	5.69	0.00
(fs)	1.36	1.83	2.08	0.44	3.22	2.48	2.30	1.66	0.00
di	9.15	13.35	19.31	1.81	37.79	14.32	18.78	14.71	0.00
(en)	11.93	13.84	11.91	5.59	5.17	7.26	10.46	7.05	10.37
(fs)	5.04	5.22	3.26	5.22	1.06	3.86	3.40	2.06	8.94
hy	16.96	19.05	15.17	10.81	6.23	11.12	13.85	9.11	19.30
(fo)	3.70	3.52	0.00	0.00	7.46	3.49	14.49	0.00	0.00
(fa)	1.56	1.32	0.00	0.00	1.53	1.85	4.71	0.00	0.00
ol	5.26	4.84	0.00	0.00	8.99	5.34	19.20	0.00	0.00
mt	2.39	0.77	2.50	6.19	1.94	2.83	1.90	3.72	3.34
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.36	0.84	1.93	3.23	1.14	4.00	1.71	1.65	3.41
ap	0.15	0.15	0.00	2.18	0.00	0.00	0.00	0.79	0.94
py	0.03	0.01	0.01	0.02	0.01	0.01	0.02	0.09	0.01
cc	0.90	2.01	0.00	0.00	0.18	0.00	0.00	0.26	2.62

	PS 81-13	PS 81-71	PS 81-82	PS 81-86	PS 81-91	PS 78-18	PS 78-124	PS 79-6	PS 79-14	PS 79-77
	IFg	IFg	IFg	IFg	IFg	IFp	IFp	IFp	IFp	IFp
	%	%	%	%	%	%	%	%	%	%
SiO_2	55.04	48.17	46.52	49.67	49.31	70.42	79.50	76.47	71.56	79.87
TiO_2	1.83	0.72	0.92	1.19	0.98	0.26	0.20	0.24	0.31	0.13
Al_2O_3	15.87	18.87	15.95	17.03	13.48	15.56	12.76	12.22	13.81	10.26
Fe_2O_3	3.21	2.39	1.94	3.34	2.58	0.46	0.35	0.12	0.47	0.49
FeO	7.84	4.65	6.51	4.65	6.64	1.54	0.00	0.40	1.06	0.26
MnO	0.22	0.13	0.14	0.14	0.16	0.01	0.00	0.00	0.03	0.00
MgO	2.82	7.07	11.55	6.82	10.83	2.95	0.00	0.12	0.62	0.32
CaO	6.71	12.01	10.93	12.01	11.84	0.05	0.00	0.42	1.36	0.01
Na_2O	3.63	3.07	2.08	3.04	2.54	0.65	6.99	2.66	3.35	0.15
K_2O	0.08	0.26	0.07	0.13	0.22	4.88	0.07	4.68	3.33	6.99
P_2O_5	0.48	0.07	0.07	0.15	0.07	0.08	0.16	0.11	0.34	0.00
H_2O+	2.24	2.78	3.34	2.31	1.99	2.35	0.36	0.28	0.82	0.66
H_2O-	0.12	0.07	0.18	0.13	0.11	0.24	0.16	0.13	0.14	0.11
S	0.02	0.01	0.02	0.00	0.03	0.01	0.01	0.08	0.02	0.05
CO_2	0.34	0.07	0.10	0.38	0.48	0.29	0.15	0.38	0.86	0.10
Total	100.45	100.34	100.32	100.99	101.26	99.75	100.71	98.31	98.08	99.40
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	12	15	24	17	24	3	2	2	2	<2
Cr	4	36	220	52	129	6	6	4	4	3
Cu	4	5	85	6	5	8	8	3	3	3
Mo	<3	<3	<3	<3	<3	<2	<2	<3	<3	<3
Ni	<2	36	135	30	68	4	<2	<2	<2	<2
Pb	5	<3	3	<3	6	20	9	6	19	16
Zn	52	35	44	31	46	70	11	<5	38	69
V	107	147	155	185	230	15	<5	<10	13	<10
Zr	115	21	40	61	40	150	85	163	193	53
Y	45	13	16	24	20	12	5	10	23	7
Sc	16	25	23	30	33	6	<4	7	10	<4
Li	12	23	9	11	13	95	<2	<5	<5	33
Nb	—	—	—	—	—	<6	<6	—	—	—
	%	%	%	%	%	%	%	%	%	%
Q	12.57	0.00	0.00	0.30	0.00	41.40	35.40	41.23	36.48	50.47
or	0.49	1.56	0.42	0.78	1.29	30.21	0.41	28.70	20.43	43.47
(ab)	34.08	27.39	18.97	27.57	22.72	6.12	62.20	24.80	31.24	1.42
(an)	28.00	37.42	34.51	32.77	24.64	0.00	0.00	0.00	0.00	0.00
pl	62.08	64.80	53.48	60.34	47.36	6.12	62.20	24.80	31.24	1.42
(wo)	1.41	8.81	7.78	9.60	12.16	0.00	0.00	0.00	0.00	0.00
(en)	0.71	7.09	6.28	8.12	9.77	0.00	0.00	0.00	0.00	0.00
(fs)	0.70	1.72	1.50	1.48	2.39	0.00	0.00	0.00	0.00	0.00
di	2.83	17.62	15.57	19.20	24.33	0.00	0.00	0.00	0.00	0.00
(en)	7.43	0.00	7.90	10.90	9.13	8.54	0.00	0.34	1.78	0.93
(fs)	7.32	0.00	1.89	1.99	2.24	1.78	0.00	0.07	0.93	0.00
hy	14.75	0.00	9.79	12.89	11.36	10.32	0.00	0.41	2.71	0.93
(fo)	0.00	9.51	13.65	0.00	8.17	0.00	0.00	0.00	0.00	0.00
(fa)	0.00	2.30	3.27	0.00	2.00	0.00	0.00	0.00	0.00	0.00
ol	0.00	11.81	16.92	0.00	10.17	0.00	0.00	0.00	0.00	0.00
mt	3.51	2.53	2.06	3.53	2.69	0.50	0.00	0.13	0.51	0.21
cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
il	2.67	1.02	1.30	1.67	1.36	0.38	0.00	0.35	0.45	0.19
ap	1.05	0.15	0.15	0.32	0.15	0.08	0.00	0.24	0.74	0.00
py	0.02	0.01	0.02	0.00	0.03	0.01	0.00	0.07	0.02	0.05
cc	0.00	0.18	0.26	0.97	1.21	0.00	0.00	0.57	1.88	0.02

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